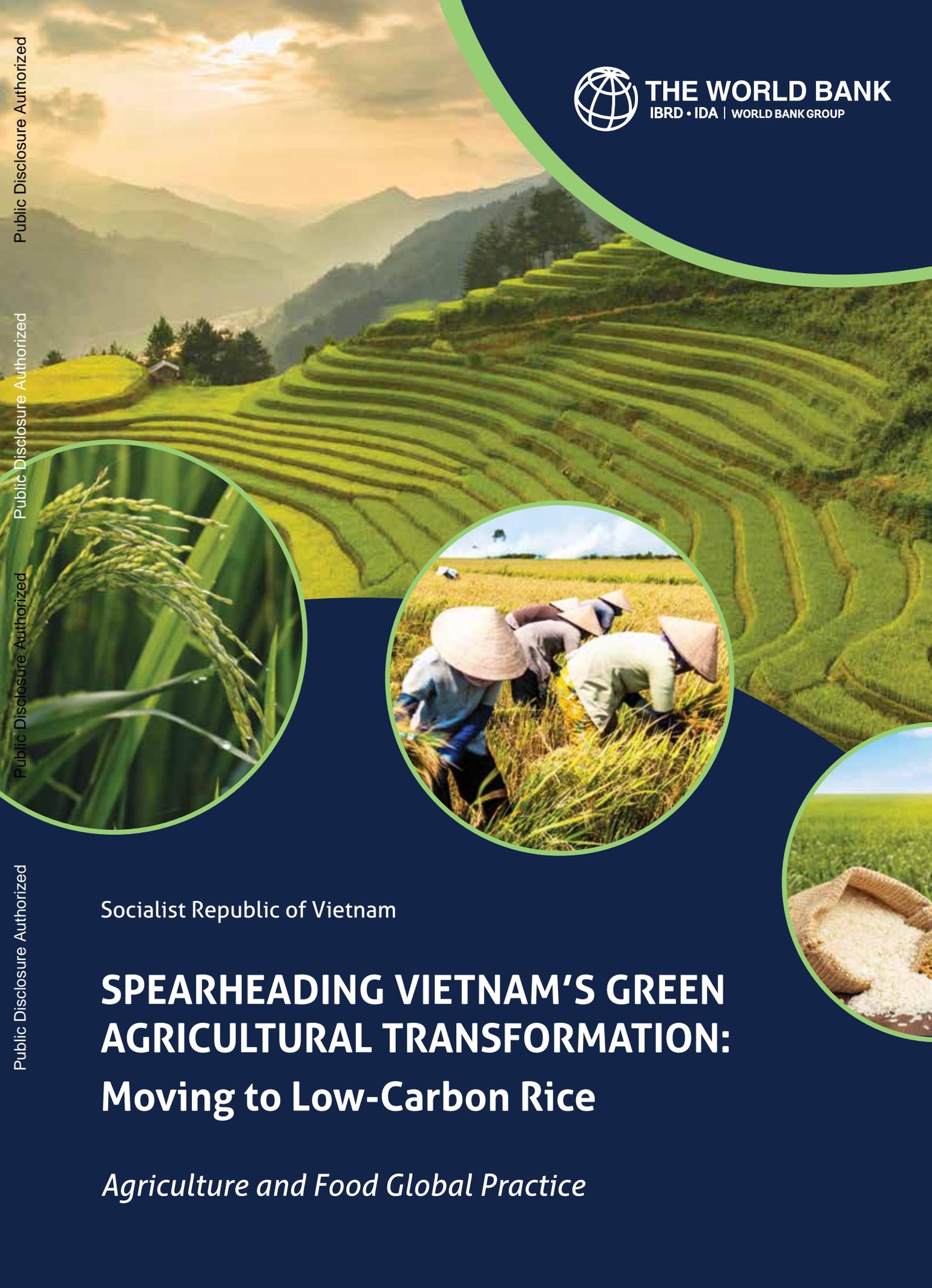


Socialist Republic of Vietnam

SPEARHEADING VIETNAM'S GREEN AGRICULTURAL TRANSFORMATION: Moving to Low-Carbon Rice

Agriculture and Food Global Practice



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ACRONYMS AND ABBREVIATIONS

1M5R	One Must Five Reductions
3R3G	Three Reductions, Three Gains
ACP	Agriculture Competitiveness Project
AFD	French Development Agency (<i>Agence Francaise de Developpement</i>)
AFF	Agriculture, Forestry, and Fisheries
AFOLU	Agriculture, Forestry, and Other Land Use
AMIS	Agricultural Market Information System
ARP	Agricultural Restructuring Plan
AWD	Alternate Wetting and Drying
BAU	Business-as-Usual
CCDR	Country Climate and Development Report
CER	Certified Emission Reduction
CF	Continuously Flooded
CGE	Computable General Equilibrium
COP26	2021 United Nations Climate Change Conference
CPSD	Country Private Sector Diagnostic
CSA	Climate-Smart Agriculture
CSRP	Climate-Smart Rice Planting
DARD	Department of Agriculture and Rural Development
EDF	Environmental Defense Fund
EPT	Environmental Protection Tax
ERPA	Emission Reductions Payment Agreement
EU	European Union
FAO	Food and Agriculture Organization
FAOSTAT	FAO Statistical Database
FCPF	Forest Carbon Partnership Facility
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIZ	German Agency for International Cooperation (<i>Deutsche Gesellschaft für Internationale Zusammenarbeit</i>)
GNI	Gross National Income
GOV	Government of Vietnam
GSO	Government Statistical Office
IDA	International Development Association
IFC	International Finance Corporation
IFPRI	International Food Policy Research Institute
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
IoT	Internet of Things

IPCC	Intergovernmental Panel on Climate Change
IPSARD	Institute for Policy and Strategy for Agriculture and Rural Development of Vietnam
IRRI	International Rice Research Institute
LCT	Low-Carbon Transition
LULUC	Land Use and Land Use Change
LUR	Land Use Right
M&E	Monitoring and Evaluation
MACC	Marginal Abatement Cost Curve
MANAGE	Mitigation, Adaptation, and New Technologies Applied General Equilibrium
MARD	Ministry of Agriculture and Rural Development
MFI	Microfinance Institution
MKD	Mekong Delta
MOF	Ministry of Finance
MRV	Measuring, Reporting, and Verification
NCCS	National Climate Change Strategy
NDC	Nationally Determined Contribution
NDC-ISP	Nationally Determined Contribution Implementation Support Plan
NGO	Nongovernmental Organization
NPK	Nitrogen, Phosphorus, and Potassium
NSGG	National Green Growth Strategy
OECD	Organisation of Economic Co-operation and Development
R&D	Research and Development
SAM	Social Accounting Matrix
SDGs	Sustainable Development Goals
SOE	State-Owned Enterprise
SRP	Sustainable Rice Platform
TFP	Total Factor Productivity
UNFCCC	UN Framework Convention on Climate Change
VHLSS	Vietnam Household Living Standards Survey
VIDA	Vietnam Digital Agriculture Association
VNSAT	Vietnam Sustainable Agricultural Transformation Project
WDI	World Development Indicators
WRI	World Resources Institute

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EXECUTIVE SUMMARY

- This report focuses on promoting low-carbon rice production systems in Vietnam.** There are many sources of greenhouse gas (GHG) emissions within the agricultural sector in Vietnam, including along value chains and within the whole agri-food context. However, because rice production is so important to the country and to emission reductions in agriculture, this report focuses on known actions that can be rapidly upscaled, along with other complementary actions to reduce GHG emissions from rice production systems. The report covers emission reduction pathways in rice. It does not cover emission reductions from other agriculture, forestry, and other land use (AFOLU) changes.
- Vietnam's agricultural sector has supported both growth and poverty reduction, yet the sector must urgently transform to sustainable and low-carbon practices.** Since the 1990s, Vietnam's agriculture has maintained a relatively steady growth rate of 2.5 – 3.5 percent per year. It now contributes about 14 percent of gross domestic product (GDP) and about 38 percent of employment. The sector played a major role in reducing poverty to less than 6 percent, bringing about almost zero food insecurity, maintaining social stability, and with many agricultural commodities, including rice, coffee, cashew, pepper, fruits, vegetables, and seafood entering global markets, earning the country over US\$48 billion per year in export revenues in 2021.
- Vietnam's agricultural sector is however at an inflection point.** The impressive growth of the agricultural sector and its export competitiveness are threatened by environmental degradation and climate change impacts. Degraded ecosystems are less productive and cannot supply vital services upon which agriculture depends, such as freshwater stocks and healthy soils. Climate change impacts are expected to result in projected yield losses across many crops, especially cereals such as rice, from heat and droughts. Climate change impacts may already be reducing rice yields, and projections show that production could drop by over 6 percent by 2030 and over 13 percent in 2050, while rice prices rise causing food insecurity particularly among the poor who spend most of their incomes on food. The most vulnerable agroecological areas of the country such as the Mekong Delta (MKD) and the Red River Delta are likely to be affected more due to increasing frequency of droughts, floods, and saltwater intrusion. In spite of these challenges, Vietnam plans to rank among the world's top 15 agricultural exporting countries by 2030. However, Vietnam's competitiveness in agricultural exports may be negatively affected by heightened international attention to the carbon footprint of its exported commodities.
- Vietnam has recognized these challenges and has made international commitments both to reduce global GHG emissions and to adopt green growth strategies across multiple sectors, including agriculture.** The agriculture sector will play a critical role in meeting Vietnam's Nationally Determined Contribution (NDC), including commitments to the United Nations Framework Convention on Climate Change (UNFCCC) to cut methane emissions by 30 percent by 2030 and achieve net-zero levels by 2050 as part of its 2021 United Nations Climate Change Conference (COP26) commitments.¹ The government's new Strategy for Sustainable Agriculture and Rural Development for 2021–2030 with a Vision to 2050, approved through the Prime Minister's Decision No. 150/QĐ-TTg of January 28, 2022, prioritizes resilient, green, low-carbon agricultural transformation.

1 Vietnam's NDC targets to cut GHG emissions by 6.8 million tCO₂e per year by 2030 (unconditional, using own public resources) and 25.8 million tCO₂e per year by 2030 (conditional target with external support). In the updated NDC, the emission reductions targets were increased to 9 and 27 million tCO₂e per year by 2030 for the unconditional and conditional targets, respectively.

5. **There is a realization that agriculture, with all its successes, is a major contributor to GHG emissions in Vietnam.** It is the second highest emitting sector, accounting for about 19 percent of total national emissions (in 2020). About half (48 percent) of the agricultural sector emissions and over 75 percent of methane emissions come from one single commodity, rice. Rice is Vietnam's most important crop, cultivated on over 54 percent of the land and much higher in the MKD (the country's major rice bowl) and the Red River Delta. Rice provides food security to over 90 percent of the population and contributes over 30 percent of total agricultural output. Vietnam now produces over 43 million tons of paddy (unprocessed rice), out of which the country exports on average over 6 million tons of rice (about 9 percent of global rice exports by volume), earning the country over US\$3 billion in export revenue. However, significant reductions in rice production are challenging, as it is critical for food security, farmers' livelihoods, and exports. It is thus essential for Vietnam to transition to low-carbon rice production as a step toward sustainable low-carbon agricultural transformation.
6. **Transitioning to low-carbon rice production requires shifting away from the production practices that cause large GHG emissions.** Many key drivers increase GHG emissions in Vietnam's rice production, including (a) inefficient water use for irrigation, (b) very high seeding density and inefficient and high fertilizer application rates, (c) improper management of rice residues such as rice straw and husks, and (d) inefficient energy use in agriculture. Rice is grown in flooded conditions, such that the water blocks oxygen from penetrating the soil, creating ideal conditions for bacteria to thrive on decomposing organic matter, mainly rice straw residue, and release methane (Earth Security Group 2019). Poor absorption by the rice plants of nitrogen-based fertilizers, which are often overused by farmers, further leads to nitrous oxide emissions.
7. **This report assesses agronomic and other options that offer technically and economically feasible pathways to promote low-carbon rice.** Some options have been piloted in Vietnam and require significant upscaling at the farm level. Scaling up the no-regret options with the most economic benefits can enable Vietnam to achieve higher emission reduction targets most efficiently. Farm-level, partial equilibrium, and economywide analyses show that two approaches—promoting water management through alternate wetting and drying (AWD) irrigation and optimal application of inputs through One Must Five Reductions (1M5R) techniques²—can maintain or increase yields and farmer incomes while also reducing GHG emissions. Research results in Vietnam and elsewhere show that AWD is a viable option to improve water use and reduce emissions from rice production. In Vietnam, an analysis conducted by the International Rice Research Institute (IRRI) shows that if AWD is applied consistently on about 1.9 million ha under paddy, it can result in net profits estimated at US\$2.3 billion per year while reducing GHG emissions by 10.97 million tCO₂e per year by 2030 (with a total investment outlay of about US\$3.1 billion by 2030). On a 'per hectare per year' basis, the application of AWD results in an average net profit of US\$1,211 and GHG emission reduction of 5.8 tCO₂e, based on results from Vietnam Sustainable Agricultural Transformation Project (VNSAT) and the Agriculture Competitiveness Project (ACP). Application of 1M5R reduces seed use by 29–50 percent, inorganic fertilizer by 22–50 percent, water use by 30–50 percent, and pesticide application by 20–33 percent. Consequently, production costs decline by about VND 4 million per ha (22 percent reduction), while rice yields increase by 5.2–7.9 percent and profits increase by 29–67 percent. 1M5R reduces GHG emissions by about 26.6 percent in winter-spring and 29.9 percent in the summer-autumn rice planting seasons. It should be noted that there have been significant variations in GHG reduction reported from different pilot projects in Vietnam over the past years, mainly due to different technologies applied as well as other factors such as weather, seasonal patterns, and locations. Nonetheless, the GHG reduction potential is evident and significant if AWD and 1M5R are widely and quickly scaled up compared to conventional farming practices. To go forward with

2 1 Must: Must use certified seed; 5 Reductions: reduced rates of seed, fertilizer, pesticide, water, and postharvest loss.

a national GHG reduction program, it is necessary to review approaches and initiatives and the associated GHG reduction impacts achieved in Vietnam in the past years, document the methodology used to measure GHG emission reduction for each case, establish the GHG emission baseline for each ecological region and subregion, and identify the key factors affecting emissions and areas that need standardizing to achieve better accuracy in GHG measurement and reporting and recommend the most cost-effective and scalable approaches.

8. **The application of digital technologies along with the agronomic technologies such as AWD and 1M5R has added further benefits.** Pilots conducted in Vietnam using the internet of things (IoT)—which includes water sensors to help farmers better decide on the optimal amount of water to apply—showed a reduction in water use by up to 42 percent compared to manual flooding of rice fields, cutting production costs by up to 22 percent and increasing rice yield by 24 percent (Choudhary and Fock 2020). These smart irrigation systems can reduce GHG emissions by up to 60–70 percent compared to the manual system of irrigation (equivalent to 4–6 tCO₂e per ha per crop season). IoT-based systems integrate laser sensors for precise water level measurement for automation of the AWD technique for different sizes of fields. The use of such digital techniques is upgradable by utilizing various sensors, wireless links, and internet infrastructure due to the increasing availability and decreasing cost of these technologies.
9. **The application of technical options alone, however, will not be sufficient to achieve net-zero emissions.** A net-zero pathway would require applying complementary mitigating options across all key emission-intensive sectors. Results of the computable general equilibrium (CGE) model show that combining a carbon tax and sectoral strategies results in higher GHG emission reduction. Without a carbon tax, emission reductions will reach 9.1 and 21 percent compared to the baseline by 2030 and 2040, respectively. With the carbon tax, emission reductions will reach 29 and 51 percent compared to the baseline by 2030 and 2040, respectively. The combination of sectoral policies and carbon pricing appears necessary to put the economy on the trajectory toward net-zero emissions. In the case of low-carbon rice, higher emission reductions can be achieved by significantly scaling up the package of AWD (for water use efficiency) and 1M5R (for input use efficiency) coupled with the use of digital technologies which provide additional efficiency in terms of reducing water use and production costs.
10. **The cost of transition to low-carbon rice is however quite high.** Considering the targets set under each of the scenarios defined in the NDC,³ the investment cost estimates range from about US\$110 per ha for the low-case scenario and US\$515 per ha for medium-case scenario to about US\$3,890 per ha for the high-case or net-zero scenario by 2030. Applying the same unit costs per tCO₂e will result in investment cost estimates ranging from US\$226 per ha for the low-case scenario and US\$1,085 per ha for the medium-case scenario to over US\$8,200 per ha for the high-case or net-zero scenario by 2040. These estimates assume an average abatement cost of US\$30 per tCO₂e (Escobar et al. 2019). The range of investment costs varies significantly depending on the status of irrigation infrastructure, which accounts for over 80 percent of the estimated investment costs. Experiences from the VNSAT showed that about 67 percent of the cost is required for upgrading critical/missing public infrastructure (that is, irrigation and feeder roads), 16 percent for strengthening the capacity of the Ministry of Agriculture and Rural Development (MARD) and Departments of Agriculture and Rural Development (DARDs) for better quality extension service delivery, 14 percent for farmer training, and 2 percent for technical assistance including GHG measurements and reporting. Areas with the most dilapidated irrigation infrastructure or areas that need significant land leveling will require heavy capital investments. Other necessary investments are for improving irrigation infrastructure

3 As indicated in Chapter 1, Vietnam's NDC defines the scenarios as follows: (1) Unconditional target of 6.8 million tCO₂e per year by 2030 using domestic resources, (2) conditional target of 32.6 million tCO₂e by 2030 assuming international support, (3) net-zero level by 2050. For this report, scenario 1 is 'AgriLow', scenario 2 is 'AgriMed', and scenario 3 is 'AgriHigh'.

operations and maintenance; ensuring farmers' adoption of sustainable production practices; establishing an appropriate system for measuring, reporting, and verifying carbon credits; strengthening agricultural value chains; and linking farmers to carbon markets to maximize the benefits.

11. **Findings from this study show that the longer it takes to transition, the higher the costs will be.** Also, even though the transition cost is high, the net benefit is both positive and high in the medium to long term due to the benefits from increased agriculture productivity, sustainability, and competitiveness. Moreover, moving toward low-carbon rice can also help preserve Vietnam's global export competitiveness as multinational companies and consumers in Vietnam's main export destination markets increasingly start to demand compliance with sustainable production standards to avoid carbon leakage from other countries. Also, savings accruing from multiple benefits including the value of GHG emissions abated, amount of water saved, reduction in air and water pollution, and efficiency gains from production cost reductions and savings from the repurposing of policies or environmentally harmful support measures would enhance the long-term net benefit of the transition toward low-carbon rice.
12. **To be able to scale up the application of these low-carbon rice production options, there is an urgent need for Vietnam to adjust its current approach to agricultural sector development.** The existing rice production system, for example, can reduce its GHG emission intensity significantly while maintaining or increasing productivity, by adopting approaches such as AWD and 1M5R, along with complementary technologies (including digital technologies). However, in Vietnam, the uptake of these approaches at the farm level remains low. Several factors affect farm-level uptake. Policies and regulations create a disincentive for sustainable farmer production behaviors. Public expenditure misalignment and agricultural support measures encourage high resource use intensity (for example, water, land, and inputs) and unsustainable practices by farmers. Institutional capacity challenges hamper the more effective delivery of key agricultural services. Furthermore, low rice profit margins compared to other commodities, coupled with the limited opportunities for price premiums for sustainably produced rice in Vietnam, especially at the local level, further discourage farmers from adopting low carbon technologies. All these factors reduce the incentives for farmers to shift toward sustainable low-carbon rice practices. Together, these factors also limit private sector investment in the rice sector. Other post-harvest practices, including the lack of drying facilities and warehouses and inefficient rice milling practices (that is, double milling practices from paddy to final products for export), also increase costs while contributing toward higher GHG emissions. However, the low-carbon technologies and practices help reduce production costs and increase profits for rice farmers.
13. **This report highlights five policy areas in the short to medium term to accelerate the transition to low-carbon agriculture, especially rice:** (a) ensuring policy coherence and plan-budget alignment to support the low-carbon transition (LCT), (b) repurposing policy tools and public expenditures to support the transition, (c) promoting public investments for low-carbon rice/agriculture, (d) strengthening institutions, and (e) enabling private sector and other stakeholders' participation in LCT. These are briefly summarized below. A detailed table of the recommendations including their prioritization in terms of impact (high, medium, and low) and time frame (short, medium, and long term) is also provided in Chapter 4 (see Table 8).

Ensuring policy coherence and plan-budget alignment

14. **Strengthening environmental regulations.** There is a need to strengthen and rationalize the legal, regulatory, and enforcement systems to raise environmental standards to accelerate the adoption of sustainable farming practices and achieve improved environmental outcomes. These will help manage pollutants and agrochemicals more effectively, conserve and manage natural resources and the ecosystem

more sustainably, and help increase profits for farmers and reduce GHG emissions. Specifically, this can be achieved by (a) enacting and enforcing controls on reducing excessive use of agrochemicals and fertilizers; (b) implementing and strengthening agreements on biodiversity, forests, water, and soil quality; and (c) improving the enforcement of environmental regulations and standards and certification from the farm gate to the retail sector.

15. **Land ownership and management.** It is essential to remove the legal, regulatory, and administrative barriers to allow more flexible land use—especially for the large areas of designated paddy land—and foster a more active land market. Conditions that facilitate investments in land and how land is allocated to higher-value agriculture and other uses can contribute to increasing land productivity while supporting sustainability and lowering GHG emissions. Facilitating land consolidation by strengthening the legal frameworks for transferring agricultural land use rights (LURs) (such as transfer and lease) would offer greater incentives to private investors to make long-term investments in agriculture. This could be achieved through (a) increasing the current ceiling on landholding sizes and (b) setting up a market for transferring LURs with transparent rules and low transaction/administrative costs (for example, the Provincial People’s Committees could set up these markets (Service Centers for Land Renting) to support land renting between agribusiness investors and current agriculture land users to enable larger-scale agriculture).
16. **Enhancing efficiency through economic instruments.** The use of natural resources in Vietnam is not yet efficient and effective since it does not reflect their actual scarcity value. The government can encourage more efficient resource and input use by allowing input prices to more closely reflect their scarcity value and by better targeting taxes, subsidies, property rights, and payments. Strategic use of economic instruments can be a vital component of Vietnam’s transition to a market-based system that encourages sustainability and growth by (a) reconsidering options for charging irrigation fees to improve water productivity and incentivize efficient water use, including expanding the pay-for-service principle (cost recovery in irrigation) to reduce overuse of water and promote operations and maintenance; (b) revising the support on fertilizers to reduce distortions and perverse incentives, thereby limiting fertilizer overuse and promoting healthier plant nutrient management; (c) designing and implementing pilot programs on fees or taxes on environmentally damaging inputs; (d) putting in place mechanisms for payment for environmental services and carbon emission trading, which will help establish the basis for protecting and restoring forests and other ecosystem services and proactively position Vietnam to favorably benefit from the expected boom in the international market for carbon offsets; and (e) assessing and taking needed measures to support well-functioning input and output markets. Along with other key emitting sectors, the government can put in place measures for introducing carbon pricing in agriculture, including in rice production, to expedite the transition toward low-carbon rice.
17. **The success of LCT depends upon coordinated and convergent actions by millions of stakeholders.** From farmers and input providers to processors, traders, and consumers, individual decision-makers need to change their decisions and behaviors based on their awareness and understanding of carbon costs, longer-term risks, and technological and business opportunities. It is crucial for the success and sustainability of the LCT that public policies and interventions do not send out confusing signals or create conflicting incentives and/or distortions, to the extent possible. Given that the transition to low-carbon rice/agriculture already stands at the intersection of three big agendas (climate change, agricultural development, and food security), each with its own set of objectives, drivers, policies, programs, and institutional arrangements, it becomes even more important to ensure vision, policy, and program coherence.

Repurposing policy tools and public expenditures to support the transition

18. **Reorienting public support toward low-carbon agriculture.** A large amount of the agricultural support provided in Vietnam is considered as 'environmentally harmful'. Vietnam has made progress in reducing the share of the most environmentally harmful subsidies (that is, price and output subsidies) from 97 percent in 2010 (about US\$2.49 billion) to 77 percent in 2019 (US\$0.4 billion), but they still account for the biggest share. There is a critical need for Vietnam to make agricultural support more conditional on environmental objectives. There has been limited application at scale of both regulatory and policy instruments to influence the technical choices made by millions of farmers. By providing the right incentives (for example, through targeted subsidies, taxes, or price supports), technical tools, and credible enforcement mechanisms, farmers' actions can be effectively influenced to reverse inefficient/overuse of inputs such as irrigation water, fertilizer, pesticides, and antibiotics and promote more effective use of improved seed and breeding materials and land resources. There is a need to urgently review the policy framework to assess the feasibility of phasing out the most distorting and environmentally and socially harmful forms of direct (producer) support. Redirecting subsidies toward providing training and goods and services to enable farmers to adopt more productive and profitable production practices that also produce adaptation/mitigation benefits is necessary. Developing and piloting a scheme of payments for environmental services that remunerate flows of environmental public goods (for example, biodiversity, carbon sequestration, and flood and drought control) beyond designated reference levels and targeted to environmental outcomes is another option.
19. **Supporting research and development.** Spending on research and development (R&D), science, and technology has been minimal, estimated at about 0.4 percent of total spending in the sector, compared to the average in the region estimated at 1–2 percent of agriculture GDP. Transitioning to low-carbon green agriculture requires strengthening the capacity for knowledge and innovation in the sector. Increasing public spending for science and technology R&D is critical for generating the knowledge and innovation and catalyzing the adoption of sustainable production practices to drive low-carbon agriculture transformation. This can be supported by (a) boosting public expenditures on research, development, and dissemination of new, low-carbon technologies (such as climate-resilient seed varieties, water-saving technologies, improved post-harvest technologies, and other value chain infrastructure); (b) investing in data systems and digital technologies (for example, public use datasets on agriculture production, digital farmer registry, and digital payment infrastructure) to facilitate decision-making and accelerate the transition to low-carbon agriculture; (c) creating partnerships and platforms, involving key stakeholders in the rice value chain (MARD, DARDs in the provinces, farmer cooperatives, businesses, and so on), for promoting sustainable production focused on, for example, infrastructure investments, research and innovation, and market development; and (d) assessing the feasibility of promoting private green agricultural R&D through public-private partnerships, grants, and tax credits for relevant public and private partners.
20. **Exploring viable options for financing and de-risking agriculture.** Shifting to more sustainable and lower-emission production often entails some risks and high up-front costs for most Vietnamese farmers who generally have low skills, especially in adopting advanced technologies. Switching to greener technologies may generate additional costs, and farmers must bear start-up investment costs while facing low margins, high transaction costs, and uncertain returns. There are many ways to improve access to both finance and insurance to catalyze more rapid investments in green low-carbon agriculture across Vietnam. Three categories are proposed: (a) improving financial literacy and use of collateral, (b) increasing access to carbon finance, and (c) de-risking agriculture by improving insurance.

21. **Trade measures.** Currently, the market for climate-smart rice and the supply chains for sustainably produced rice, which can reward farmers, are only in the early stages of development in Vietnam (for example, Sustainable Rice Platform [SRP]). Yet, consumers in developed countries are increasingly showing preferences for products that meet climate, workers' safety, environmental, and other health standards. The government can take some actions to rationalize the trade regime to align better with the green goals. These include (a) reviewing tariff and non-tariff barriers, and export subsidies on food and agriculture products to examine their potential impact on sustainable resource use and environmental concerns, such as biodiversity, and identify options to foster more green production practices and (b) proactively preparing various value chains to meet the demands for greener products, along with the associated conditionalities (including standards and certification) being driven by consumers in international markets.

Promoting public investments for low-carbon rice/agriculture

22. **The shift to low-carbon agriculture will require significant investments.** At the farm level, these could be in, for example, land preparation, on-farm water management, new seeds, technologies, and inputs. Beyond the farm, too, investments in new technologies, management systems, and digital approaches will be needed to ensure more efficient, 'green' use of inputs and resources. Also, the infrastructure and equipment along the rice value chain are outmoded and need to be modernized to improve efficiency along the value chain. However, current conditions in rice production and agriculture more generally are not favorable for investment by farmers or the private sector, as the analysis in this report and many others shows.
23. **The government can catalyze investments in low-carbon agriculture across Vietnam** by (a) enhancing investment capacity at the farmer level, (b) 'de-risking' investments by the private sector, and (c) promoting access to carbon finance. Mobilization of private sector capital for low-carbon agriculture is critically important. Analysis of public expenditure aligned with climate mitigation and adaptation in agriculture suggests that public spending is likely to be able to meet only 30 percent of the overall resource requirements to meet the climate targets for 2030.

Strengthening institutions

24. **The government needs to transition from direct involvement in the sector to a more facilitating role.** Experiences from other countries undergoing agricultural transformation show that state-led development has to give way to more flexible systems to help the agri-food sector nimbly respond to new challenges arising from international markets, geopolitical situations, and climate change. Toward this end, it is critical to establish well-defined property rights (including clear and enforceable contracts), promote inclusive planning, and strengthen administrative capacity of provincial offices and local tiers. Although state control and management in both input and output markets has declined over time, more needs to be done in this regard. The share of agribusiness in agricultural sector GDP is among the lowest in Vietnam.
25. **Institutional alignment, awareness, training, and capacity building.** The institutional capacity for effective implementation of the low-carbon agenda remains a challenge due to (a) institutional obstacles to regulating production, agricultural input and output markets, enforcement of environmental regulations, and land fragmentation; (b) the sector's limited capacity to generate and disseminate information transparently, leading to an information asymmetries problem; (c) limitations in policy coordination and implementation between the center and the provincial agencies; and (d) the slow pace of institutional capacity development to drive innovation and increase efficiency. There is a need for government to transition from direct involvement in the sector to a more facilitatory role. Experiences from other countries undergoing agricultural transformation show that state-led involvement is rarely sufficiently flexible to

help the sector respond to new challenges arising from international markets, geopolitical situations, and climate change. Institutional strengthening is critical in establishing well-defined property rights (including clear and enforceable contracts), strengthening provincial governments' planning and administrative capacity, and organizing agricultural production. At the regional level, the government should promote interprovincial links through a coordinating board to share information and manage natural resources (that is, land, water, flood control, salinity prevention, natural disaster prevention, value chain management, and so on).

Enabling private sector participation in LCT

26. **Building partnerships with the private sector.** Private sector investments in agriculture remain low in Vietnam, especially compared to other sectors. Private sector investments in agriculture, fisheries, and forestry sectors account for only 1.3 percent of total registered businesses in Vietnam, and over 95 percent are small and medium enterprises, and half are microenterprises (with less than 10 employees). Enterprises cite the relatively high cost of starting and running a business, in terms of bureaucratic red tape, unfair competition with state-owned enterprises (SOEs), limitations and administrative procedures required to access land, and the reluctance of banks to lend to agro-based businesses. There is a strong need to create a better enabling environment and facilitate conditions for greater private sector entry. Key activities for fostering greater smallholder inclusion in value chains include (a) supporting development of digital platforms and service providers who can help match producers and service providers with final customers, reducing intermediaries and transaction costs; (b) leveraging digital technologies for improving traceability (for example, sensors, e-platforms, and blockchain) to facilitate end-to-end traceability in the supply chain, increase consumer trust, and facilitate the development of niche markets with favorable price premiums; (c) establishing technology funds and associated protocols to support green entrepreneurs, especially among the younger (millennial) and more tech-savvy farmers; (d) reducing the digital divide between rural and urban areas by working with the private sector and other stakeholders; (e) supporting farm clusters and 'horizontal' integration to enhance coordination and resource sharing among farmers because rice growing is particularly well suited for collective action; (f) promoting farmer links with sustainable productive alliances, such as the SRP. Overall, there is a need to rethink the relative roles of the public and private sectors to spearhead green, low-carbon agricultural transformation in Vietnam.



CHAPTER 1

THE NEED FOR A LOW-CARBON TRANSITION IN VIETNAM'S AGRICULTURAL SECTOR

Key messages

- Vietnam's agricultural sector is at an inflection point. It has supported both growth and poverty reduction, but there is now an urgent need to transform and adopt sustainable and low-carbon practices to maintain growth.
- Agriculture, and especially exports, are economically crucial, and Vietnam plans for its agri-food sector to rank among the world's top 15 agricultural exporting countries by 2030.
- Both culturally and economically, rice is Vietnam's most important crop, and production is declining due to environmental challenges and climate impacts.
- Rice contributes about half of Vietnam's agricultural sector's greenhouse gas (GHG) emissions.
- Vietnam's competitiveness in agricultural exports may be negatively affected by heightened international attention to the carbon footprint of exported commodities.
- Like other countries, Vietnam has made international commitments to cut GHG emissions, particularly methane emissions, by 30 percent by 2030 compared to 2020 levels and achieve net-zero emissions by 2050.

INTRODUCTION

1. **Vietnam's agricultural sector has been successful in supporting both growth and poverty reduction, yet the sector must urgently transform to sustainable and low-carbon practices to maintain growth.** The agriculture sector has successfully increased agricultural productivity and output growth and registered structural change after the country adopted the market-based economic policy reforms (popularly known as *Đổi Mới*) in the 1980s.⁴ The sector has played a major role in reducing poverty, improving food security, maintaining social stability, and entering global markets. Vietnamese agriculture has had a relatively steady growth rate of 2.5–3.5 percent per year since the 1990s. Agriculture now contributes about 14 percent of the gross domestic product (GDP) and about 38 percent of employment (GSO 2020). Taking into account the country's agri-food system, which includes agriculture's downstream processing, input production, and trading and transport, the contribution to GDP is even greater—by about 10 percentage points (Sutton et al. 2019). Steady advances in smallholder rice productivity and intensification since the 1990s have played a central role in Vietnam's successes.
2. **Vietnam is an agricultural commodity powerhouse and is one of the world's leading exporters of agricultural commodities,** ranking among the top five global suppliers of fish, rice, coffee, tea, cashew nuts, black pepper, rubber, wood products, and cassava.⁵ By 2020, Vietnam had become a major supplier in more than eight key global food value chains, earning total agricultural export revenues of over US\$48 billion in 2021. Vietnam currently ranks as the first, second, and third largest exporter of cashews, coffee, and rice, respectively. The structure of agricultural exports has broadened from a few commodities in the 2000s to over 10 commodities in 2020 (Appendix 1, Figures A1.1 and A1.2). Vietnam has high aspirations for its agri-food sector, with plans to rank in the world's top 15 agricultural exporting countries by value by 2030.
3. **While Vietnam has shown stellar performance in agriculture, sector growth is slowing.** Overall agricultural sector growth was estimated at 2.6–3.0 percent per year from 2011 to 2015 and about 3 percent per year on average since 2016. Annual average agricultural value-added growth has recently been 3 percent

4 Vietnam has had one of the fastest structural transformations of any low-income agrarian nation in history over the past three decades (Yanyan Liu et al. 2020). Since the *Đổi Mới* reforms in late 1986, aiming to create a robust, socialist-oriented, market economy out of a fully centrally planned one, Vietnam has consistently had well-above-average real GDP growth of 4–8 percent annually. From 1992 to 2016, per capita real gross national income (GNI) more than tripled from less than US\$500 per year (in constant 2010 dollars) to roughly US\$1,700, while the share of GDP in agriculture fell from 34 percent to 16 percent and the share of the workforce employed in agriculture fell from 68 percent to 42 percent (World Bank 2021).

5 From 2010, Vietnam doubled the number of commodities where it ranked among the top five global suppliers.

compared to over 5 percent in the decade before 2010. Total factor productivity (TFP) contribution to sector growth is also declining (Appendix 1, Figure A1.3).

4. **Rice is Vietnam's predominant agricultural crop, with special cultural significance, and is an important source of income, jobs, national and global food security, and export revenue.** Rice production accounts for 30 percent of the country's total agricultural production value (Maitah Kamil et al. 2020)⁶ and provides food security to over 90 percent of the population. Vietnam now produces over 40 million tons of paddy, out of which the country exports on average over 6 million tons (about 9 percent of global rice exports by volume), earning the country over US\$3 billion in export revenues. It is a symbol of Vietnamese culture and a staple food source that is also used to produce wine, noodles, vinegar, and crackers. Rice is cultivated on over half of the country's arable land, mostly (54.5 percent) in the Mekong Delta (MKD) region. In 2020, the total area planted to rice was 7.28 million ha (see Appendix 1, Table A1.1). Vietnam is also one of the top five rice exporting economies in the world, selling at a low price and with low production costs. Exported rice mainly goes to Asian, African, and Middle Eastern markets.
5. **Recent trends indicate that rice production is facing challenges.** Between 2015 and 2020, there were declines in (a) total paddy production in tons, (b) area under rice production, (c) total milled rice volume, (d) per-capita and total rice consumption in volume, (e) non-food use of rice, (f) rice surplus volume, (g) rice exports in both tons and value, and (h) rice export percentage in agricultural value added. The only positive indicator for rice in the same period was an increase in agricultural value added (see Appendix 1, Table A1.1).
6. **Vietnam's agricultural sector is both a victim of and a contributor to climate change, which threatens future growth, livelihoods, and food security.** Rising temperatures, more volatile rainfall, and increasing frequency of severe weather events (droughts, floods, strong typhoons) have reduced crop yields in many regions of Vietnam. Climate change impacts on agriculture are more severe in areas with higher initial temperatures and areas with marginal or already degraded lands and with limited adaptation capacity, such as the MKD. The MKD, Vietnam's food bowl, is increasingly threatened by the effects of climate change, particularly droughts, floods, typhoons, saltwater intrusion, and sea level rise, which have contributed to the destruction of crops and rural infrastructure. More volatile rainfall and temperatures have affected both crop development and yields and fostered increased pest and disease incidences.
7. **Vietnam's past agricultural growth model is unsustainable because of increasing environmental degradation and high carbon intensity.** Past agricultural growth has led to significant deforestation and forest degradation,⁷ biodiversity loss, and reduced fisheries resources while increasing land degradation, water and air pollution, and GHG emissions. These impacts further heighten Vietnam's vulnerability to climate change. Unsustainable production practices, including overuse of fertilizers, pesticides, and veterinary drugs and inefficient use of water in irrigation systems, increasingly undermine the natural resource base for continued future growth. This precarious relationship to climate change worsens Vietnam's agriculture and environmental challenges, especially in its most productive agroecologies, such as the MKD, which are increasingly affected by sea level rise, saltwater intrusion, extreme temperatures, and changing rainfall patterns.

6 Maitah Kamil et al. 2020. Rice as a determinant of Vietnamese sustainability. *Sustainability* 2020, 12, 5123; doi:10.3390/su12125123. www.mdpi.com/journal/sustainability 2020.

7 Forest clearing and degradation are major issues in Vietnam. Forest cover has increased recently, but this increase is due to forest plantations. Natural forest area and quality have declined, with roughly two-thirds of current forests rated as poor quality (for example, low stock and density), with low productivity and reduced ecological value. Mangrove area shrank by 72 percent from 1950 to 2000. The rate of net loss has been less since 2000 (partly due to replanting) but still about 900 ha per year. This analysis focuses on strategies to reduce emissions from rice production. Other broader and complex issues will be covered in other key analytical works such as *Green Vietnam* and *Country Climate and Development Report (CCDR)* which will inform the broader green growth agenda, a major priority for the World Bank's support to Vietnam.

8. **Vietnam's environmental challenges are negatively affecting agriculture by limiting the sector's resilience to climate change and its competitiveness in global markets that are increasingly rewarding greener, low-carbon production.** With rising labor costs and rural household living standards and expectations, questions have emerged about the sector's ability to continue to compete internationally as a low-cost producer of bulk undifferentiated commodities. Vietnam's agricultural sector also faces intensified domestic competition—from cities, industry, and services—for available labor, land, and water.
9. **Vietnam's agri-food sector ambitions will face trade disadvantages if the agricultural production model continues with 'business as usual' (BAU) on climate change and the environment.** Internationally traded agri-food commodities will face much higher environmental standards in the future, applied by a combination of importing country regulators, private buyers, and environmentally sensitive consumers. For example, the European Union (EU) is the third main destination for Vietnam's agricultural exports, receiving about 12.4 percent of Vietnam's agricultural exports valued at US\$5.1 billion in 2020 (Appendix 1, Figure A1.5). The EU is discussing a 'Green Deal' which would reduce carbon leakage through imports from countries with highly carbon-intensive production systems. Initial impacts of decarbonization in EU agriculture will lower EU production and create export opportunities for third-party countries. Access to the EU market, however, will increasingly be conditioned on meeting sustainability standards, making it vital for exporting countries to demonstrate compliance with higher sustainability standards. Other key exporters, such as Brazil, are already enhancing their strategies to promote the sustainability of production chains to get ahead of the curve and secure international markets for their commodities. This is a potential threat that makes it important for Vietnam to move to low-carbon production systems.
10. **Climate change and the related unsustainable use of agricultural land will trigger further natural capital depletion, worsening agricultural yields.** Climate-induced extreme weather events will also push most farmers into the fringes of fragile ecosystems, further depleting natural capital and heavily discounting any future growth prospects. Thus, preserving the country's natural capital is critical to safeguarding agriculture and Vietnam's long-term economic development. Depleting the country's natural capital—assets such as forests, water, fish stocks, minerals, biodiversity, and land—threatens long-term development and may stall progress on poverty reduction and sustainable development objectives.⁸ Market failures or institutional shortcomings have contributed to efficiency losses, and the sector's environmental costs have neither been internalized by producers nor reflected in the competitive pricing of Vietnam's commodity exports. Vietnam needs to better value its natural resources and ecosystem services to inform policy and decision-making.
11. **Vietnam's transition to low-carbon agriculture is both necessary and urgent.** First, to safeguard agricultural sustainability, there is a need to both mitigate and adapt to climate change impacts, especially in the most productive landscapes, such as the MKD, where climate change will have major negative effects on agricultural production systems. Second, at the 2021 United Nations Climate Change Conference (COP26) held in Glasgow, Scotland, Vietnam made international commitments to cut GHG emissions toward net-zero levels by 2050, so proactive actions must begin soon to achieve the commitment targets. Third, following COP26, it is likely that competitive market pressures will appear. These pressures are mainly due to (a) growing carbon-sensitive consumer demands, (b) other major agriculture-exporting countries such as Brazil that are enhancing the sustainability of their production chains to secure international markets, and (c) rising regulatory standards in the major export markets. It is thus imperative for Vietnam to start laying a strong foundation for a green low-carbon agriculture sector that will sustain its position as an agricultural powerhouse in the medium to long term.

8 A discussion of Vietnam's environmental challenges is beyond the scope of this paper but is well summarized in the literature, for example, World Bank (2021b).

12. **This report considers challenges and practical actions and policy reforms to address these challenges for Vietnam’s low-carbon transition (LCT) in rice.** Vietnam has recognized the need to act. Thus, this report emphasizes the technical and economic feasibility of readily available and scalable solutions and technologies to achieve reduced emissions in rice production. The report covers emission reduction pathways in rice. It does not cover emission reductions from other AFOLU changes.

VIETNAM’S GREEN GROWTH STRATEGY AND ITS AGRICULTURE SECTOR IMPLICATIONS

13. **Vietnam has recognized these challenges in recent policy documents, including the 2021 Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) as well as Vietnam’s commitments made at COP26 held in 2021.** Specifically, Vietnam identified in the NDC Implementation Support Plan (NDC-ISP) several strategies for rice production that can reduce emissions to meet the targets (Box 1). This report examines the economics, emission reduction potential, and challenges for two of the NDC-identified strategies. The report also provides recommendations across multiple sectors to facilitate a transition to low-carbon rice and strengthen the country’s capacity to transition to a sustainable, adaptive, and resilient agricultural sector.

Box 1: Vietnam’s commitments to GHG emission reductions

At COP26 in Scotland, held in 2021, Vietnam’s Prime Minister Pham Minh Chinh pledged to reduce methane emissions by 30 percent by 2030 compared to the 2020 level and achieve net-zero emissions by 2050. To achieve these emission reduction targets, the government launched the NDC Implementation Support Plan (ISP). The overall objective of the NDC-ISP is mobilizing domestic and international resources to support the effective implementation of Vietnam’s commitments on reducing GHG emissions, promoting green growth, adapting to climate change, and monitoring and evaluating the implementation of contributions committed by Vietnam under the NDC. Specific objectives include supporting institutions in promoting NDC implementation and strengthening capacity for regulatory agencies and stakeholders in NDC implementation for 2021–2030, improving mechanisms and policies to respond to climate change, reviewing and evaluating the current system of policies and laws, and strengthening capacity on climate change law enforcement and NDC implementation.

Source: MONRE 2021; <https://hanoitimes.vn/pm-ends-cop26-with-strong-commitments-rom-vietnam-319167.html>.

14. **Vietnam adopted the National Climate Change Strategy (NCCS) and a new National Green Growth Strategy (NSGG)⁹ for 2021–2030, with a Vision to 2050, showing the government’s approach and paving the way to adopting other national, subnational, and sectoral strategies.** The overall goal of the NSGG is accelerating economic restructuring to achieve economic prosperity, environmental sustainability, and social equality. At the sectoral level, the strategy expands its scope, adding science and technology, digital transformation, innovation and improvements in targets, monitoring and evaluation (M&E), and a results framework. The targets include parameters such as data analytics, cost-benefit analysis, and socioeconomic impact assessments and alignment with key international instruments such as the Sustainable Development Goals (SDGs) and the Paris Agreement.
15. **Vietnam NDC submission to the UNFCCC focuses on achieving emission reductions in energy, transport, and agriculture by providing a policy framework for addressing climate change in the economy.** In the agricultural sector, the NDC-ISP aims to reduce GHG emissions by 6.8 million tCO₂e by 2030 compared to the BAU scenario, under an unconditional target without external assistance, and/or 32.6 million tCO₂e by 2030 compared to the BAU scenario under a conditional target with external assistance. These reductions are to be

⁹ Replacing the 2011 Vietnam Green Growth Strategy in 2021, the Deputy Prime Minister signed Decision No. 1658/QĐ-TTg formalizing the new NSGG.

achieved through interventions in the key emitting subsectors such as rice, livestock, and land use and land use change (LULUC).

16. **Vietnam has placed a renewed emphasis on scaling up green, low-carbon agriculture.** Vietnam's Ministry of Agriculture and Rural Development (MARD) has formulated a new Strategy for Agriculture and Rural Development for 2021–2030 with a Vision to 2050, which was approved on January 28, 2022 (through Prime Minister's Decision No. 150/QĐ-TTg). The new strategy shows that authorities recognize that Vietnam's agricultural sector needs to move away from a volume-based growth model that depends on the intensive use of chemical inputs and cheap labor to a new goal with a commitment to an 'Ecological agriculture – Vibrant Countryside – Innovative Farmers'. The new strategy aims to transform Vietnam to a 'Transparent – Responsible – Sustainable' food supplier. This new agricultural production model for Vietnam needs to ensure that it will meet global consumer demand for high-quality agricultural goods produced in a socially responsible and environmental sustainability way. Producers have a right to safe working conditions and environmental and social safeguards. Vietnam recognizes that agricultural sustainability depends on conserving resources, preserving biodiversity, reducing emissions, and adapting to climate change.

REPORT STRUCTURE

17. **This report is focused on the rice production system in Vietnam.** There are many sources of GHG emissions within the agricultural sector in Vietnam, including along value chains and within the whole agri-food context. However, rice production is so important to the country and to emission reduction in agriculture. Hence, this report focuses on known actions that can be rapidly upscaled, along with other complementary actions in the rice sector. It is not intended as an analysis of interrelated agricultural, climate, and environmental impacts. The report was developed based on reviewing the achievements and lessons from Vietnam's agriculture over the last two decades, in which the sector and the country have undergone significant structural transformation. The report has also drawn from sectoral studies undertaken since 2016 to inform the Agricultural Restructuring Plan (ARP) implementation, including the experiences and lessons from development projects supported by the World Bank in shaping Vietnam's agricultural transformation. The analysis draws from official national-level datasets such as the Vietnam Household Living Standards Survey (VHLSS) and AgroCensus and international databases including World Development Indicators (WDI) and Food and Agriculture Organization Corporate Statistical Database (FAOSTAT). The report also highlights international experiences and lessons on low-carbon agricultural development.
18. **This report is structured as follows.** Chapter 1 makes the case for the transition to low-carbon rice production as an imperative for Vietnam to sustain its decades-long stellar performance in the agricultural sector. Chapter 2 focuses on the transition to low-carbon rice as Vietnam's unsustainable rice intensification is the major contributor of GHGs, especially methane. To achieve Vietnam's national and international commitments to cut methane emissions by 30 percent by 2030, focusing on low-carbon rice production offers the highest potential, as rice production in Vietnam contributes 75 percent of agricultural methane emissions. Chapter 2 further highlights the technical options available to reduce GHG emissions from rice production. Chapter 3 provides the economics of the technically feasible transition options at the farm and macro levels and the costs associated with this transition. Chapter 4 highlights challenges and recommendations to address these issues and focuses on the right strategies, policies, and actions across sectors to rapidly facilitate a scale-up to low-carbon rice options while broadly improving the agricultural sector and building climate resilience. Appendix 1 provides supplemental information and figures to bolster the information provided within the main text. Appendix 2 gives information on complementary actions in rice production, both in Vietnam and other countries, that could greatly enhance rice productivity and resilience and reduce GHG emissions. Appendix 3 provides information on the analytical methodologies used in the report.



CHAPTER 2

OVERVIEW OF VIETNAM'S RICE PRODUCTION, PROJECTED CLIMATE IMPACTS, AND GREENHOUSE GAS EMISSIONS FROM RICE

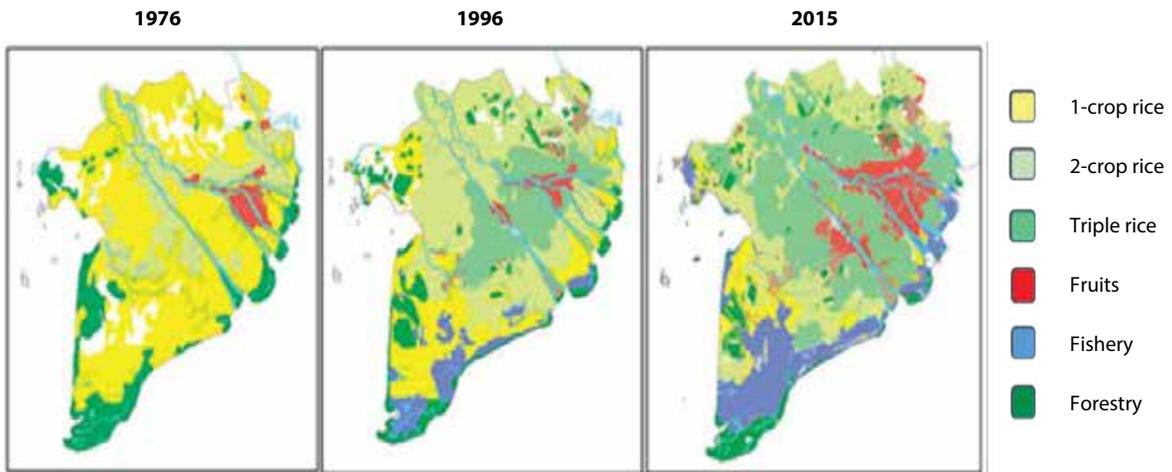
Key messages

- Supported by decades of government investment, rice is a major source of calories in Vietnam.
- Rice is less profitable and has lower margins and a weaker value chain than other crops.
- The MKD is one of the world's largest rice-growing areas, with increasing intensity of rice production over time.
- Climate change impacts may already be reducing rice yields, and projections show that production could drop by over 6 percent by 2030 and over 13 percent in 2050, while rice prices rise.
- Rice is a major source of emissions, mainly methane from anaerobic conditions in flooded paddy fields.
- There are five key drivers that increase GHG emissions in Vietnam's rice production.
- Substantially lessening rice production will not be an option in the foreseeable future.
- Promoting the transition to low-carbon rice production will be critical.

OVERVIEW OF RICE PRODUCTION

19. **Rice production in Vietnam has intensified in the past four decades.** After the national unification in 1975, the government set food security as the top priority, promoting double and triple rice cropping on an extensive scale supported by a complex system of irrigation infrastructure. In the 1980s and 1990s, Vietnam invested extensively in constructing sea dikes and coastal sluice gates and to bring more freshwater to coastal areas for rice cultivation. The International Rice Research Institute (IRRI) introduced high-yielding and short-duration rice varieties, and the two-crop rice system gradually replaced the single-season rice production system (Nguyen et al. 2017). Large investments in water regulation and irrigation systems included low and high dikes in the floodplains that prevent floodwater from reaching the rice fields and enable the harvest of a second crop during July–August and the planting of a third rice crop during the flooding season from September to December. These investments and production increases occurred mainly in the MKD. Vietnam encouraged migration to the MKD to settle and drain areas for crop production. Vietnam's rice output reached a record level of 19 million tons in 1989.
20. **These investments and policies turned the Mekong River Delta (MKD) into one of the world's largest rice growing areas.** The MKD is home to 20 percent of Vietnam's population and produces over half of Vietnam's rice and more than 90 percent of its rice export. The evolution of rice intensification in the MKD is shown in Figure 1. The MKD is known as Vietnam's "rice bowl," and its annual rice production is almost three times that of the Red River Delta. According to MARD, the MKD contributed on average about 56 percent of the total rice production between 2015–2018. The Red River Delta and the Northern Central and Coastal regions contributed about 15 and 16 percent, respectively (see Figure 2). Over 80 percent of MKD's population is engaged in rice cultivation, and nearly 55 percent of the delta's land produces rice (see Figure 3), with more than 1,600 rice varieties cultivated. Intensifying rice production has been accompanied by more area covered by aquaculture and fruit trees, increasing Vietnam's food exports.

Figure 1: Land use map of the MKD in 1976, 1996, and 2015



Source: Dang et al. 2019.

Figure 2: Vietnam: Total Rice Production

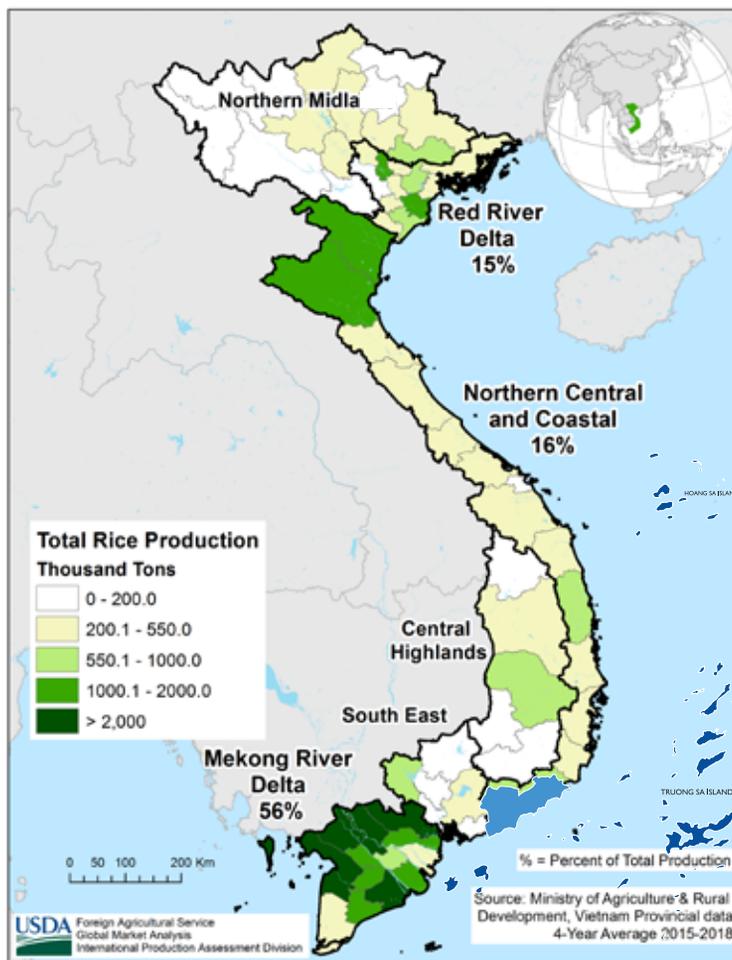
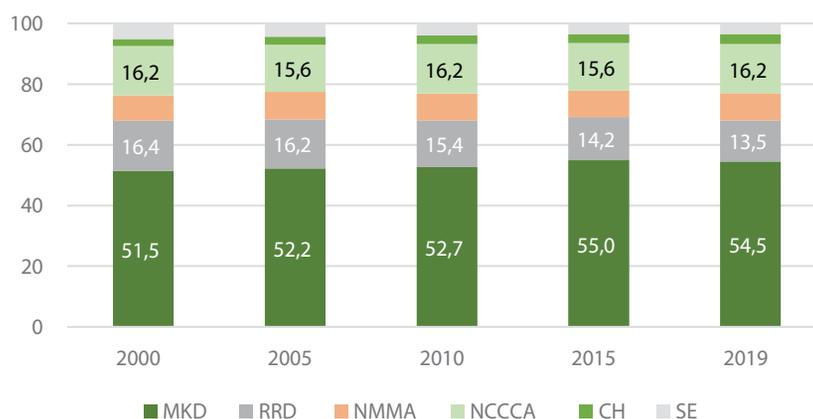


Figure 3: Rice land in Vietnam by region (%)

Source: Statistical Yearbook of Vietnam 2020.

Note: CH = Central Highlands; NMMA = Northern Mountainous Areas; NCCCA = Northern Central Coast Areas; RRD = Red River Delta; and SE = South East Region.

21. **The Government of Vietnam (GOV) has long supported policies, incentives, and controls to increase rice output and ensure supply for food security and exports.** These include a policy of ‘protecting’ rice lands by restricting their conversion either for nonagricultural use or for alternative long-term agricultural uses, such as perennial crops and aquaculture.¹⁰ The current policy sets a national target of 3.8 million ha of protected rice land.¹¹ There are also various incentives and controls to encourage provincial and local authorities to manage land use planning to retain 3.8 million ha for rice. Recent incentives include (a) per-hectare payments to paddy farmers, which were phased out in 2017;¹² (b) significant public investments in rice-related irrigation infrastructure worth more than 70 percent of the entire agricultural budget (World Bank and Government of Vietnam 2017); and (c) use of ‘paddy land’ in the budget formula to calculate the central government’s budget transfers to provinces. Earlier analyses, including the recent review of the food security policy, have recommended reducing the land under rice to 3.3–3.5 million ha by 2030 without hurting the country’s food security and rice exports.
22. **Vietnam’s rice output and yield have increased since the 1980s, although average growth has slowed in the past decade.** Compared to other major rice-growing countries, Vietnam’s paddy output and yield grew strongly by over 5 percent in terms of output and over 4 percent in terms of yield. Average growth of output and yield has remained positive throughout the past two decades since 1990, although the pace of growth of both total output and yield has been slowing down during the last decade since 2011 (Figure 4).

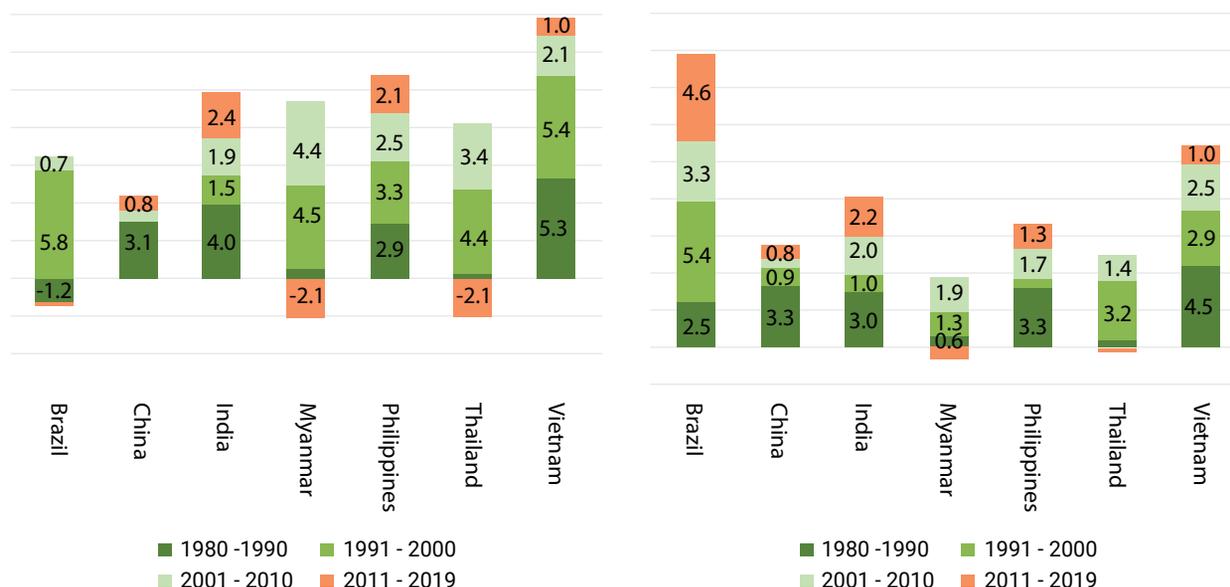
10 Decree 35/2015 permits a temporary conversion of some rice land to other annual crops.

11 MARĐ decided (Decision Number 555/QĐ-BNN-TT) on Approving Scheme for Restructuring of Vietnam’s Rice Industry by 2025 and 2030 on January 26, 2021. This decision targets rice to ensure food security and rice exports, with targets including area planted, rice yields, use of certified seeds, farmer profits, and reduction of GHG emissions from rice to 5 percent. The area planted with rice is targeted at 3.6–3.7 million ha by 2025 and 3.5 million ha by 2030.

12 According to the Decree 35/2015, farmers received VND 1 million (about US\$45) per ha per year for producing paddy. Also see OECD (2017).

Figure 4: Average growth in paddy output and yield

(a) Average paddy output growth (%), 1980 – 2019 (b) Average paddy yield growth (%), 1980-2019



Source: Estimates using data from FAOSTAT (<http://www.fao.org/faostat/en/#data>).

23. **For farmers, rice has a low profitability even though it is an important crop in Vietnam for food security and exports.** Based on the 2018 VHLSS data, average paddy net incomes per household were among the lowest relative to other commodities such as perennial crops like cashews, coffee, and pepper; livestock; fisheries; and aquaculture. According to the same 2018 VHLSS data, average farm household net income per hectare per planting cycle for rice was estimated at VND 8.763 million (US\$377) while it was VND 11.688 million for perennial crops (US\$502), VND 29.273 million for livestock (US\$1,259), and VND 20.860 million for fisheries and aquaculture (US\$897) (Appendix 1, Table A1.2).
24. **The low quality of rice further decreases its profitability and discourages adoption of more sustainable practices.** Vietnam supplies over 9 percent of global rice exports and ranks third in terms of quantity supplied, but it is tenth in rice price. Vietnam's rice quality is gradually improving, but the country remains at the lower end of the quality and price spectrum in the world rice market. The current system of rice production may not be able to support farmers' livelihoods for long. Both the productivity and the value of Vietnam's rice have to significantly improve to support the livelihoods of the majority of rice-based farmers in the MKD, Red River Delta, and other areas of the country that depend on the rice production system. Moving to low-carbon high-value rice improves the prospect of improving rice productivity and value.

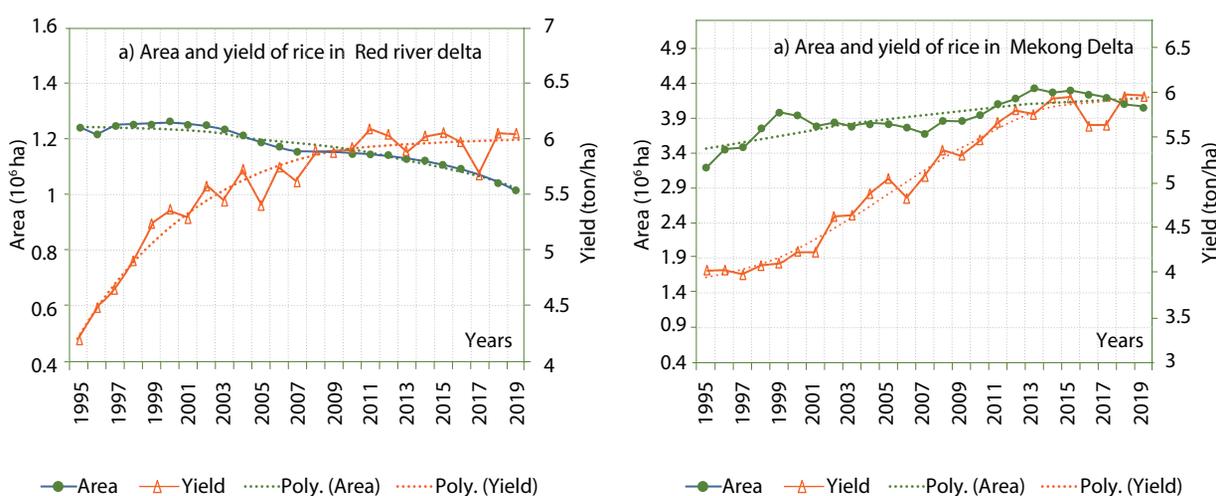
CURRENT AND PROJECTED CLIMATE CHANGE IMPACTS ON RICE PRODUCTION

25. **Climate change impacts may already be affecting Vietnam's rice production.** Vietnam's rice paddy yield has reached about 6 tons per ha and seems to be plateauing in both the Mekong and the Red River Deltas, the main rice-growing areas of Vietnam (Figure 5). Multiple studies highlight that climate-induced effects on crop production and productivity will affect crop yields and output in Vietnam over the medium to long term (World Bank and IPSARD 2020). Until the potential crop yield in a given environment is reached, yields are expected to steadily increase due to technological improvements. However, beyond the stage of the potential yield and assuming steady or slowing technological improvements, the yield growth tends to be

affected more by the variations in rainfall and temperatures as well as other extreme weather events. Model simulations show that the rice yield will decline in the medium to long term because of climate-induced weather events (Figure 5). Further simulations of the rice yield during the winter and spring seasons in selected provinces of the MKD are provided in Figure A1.7 in Appendix 1.

26. **The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT)¹³ models demographic, economic, demand, and consumption factors as well as mitigation options and the complex interplay of factors which will affect crop yield and output in the context of climate change.** IMPACT uses a partial equilibrium multi-market economic model that estimates climate change impacts on overall agricultural commodity yields and output. The International Food Policy Research Institute (IFPRI) used the IMPACT model to estimate climate change impacts on agriculture in Vietnam between 2030 and 2050 (IFPRI 2017). For Vietnam, the aggregate index of agricultural output is estimated to increase by 25 percent between 2020 and 2030 and by 36 percent by 2050, representing an annual increase of 1.1 percent and 0.8 percent, respectively. However, these rates could decline to 0.9 percent and 0.5 percent, respectively, with climate change impacts.¹⁴

Figure 5: Rice area and yield in the Mekong and Red River Deltas



Source: FAO estimates (FAOSTAT 2020, <http://www.fao.org/faostat/en/#data>).

27. **The model shows that all commodities decline in output when climate change effects are considered.** Impacts are more pronounced on cereals including rice due to their high vulnerability to climate change effects including heat, droughts, and saltwater intrusion. The model results show declining output in maize, rice, fruits and vegetables, oil seed, and roots and tubers. The rate of decline ranges from 3 percent to about 16 percent between 2030 and 2050. The largest decreases of 14 and 16 percent are for rice and maize, respectively (Table 1).

13 IMPACT is a model of the global agricultural sector that takes account of climate change as well as the economic agency. See Robinson et al. (2015) for details.

14 Since the index of crop production rose by 28 percent between 2010 and 2018 (<https://data.worldbank.org/indicator/AG.PRD.CROP.XD?locations=VN>) and the increase with climate change from 2010 to 2030 from the model is only 20 percent, a decrease of 8 percent in food production is projected between 2018 and 2030.

Table 1: IMPACT projected declines in agricultural commodity output due to climate change in Vietnam (MT, thousands)

	Climate change		No climate change		% change	
	2030	2050	2030	2050	2030	2050
Maize	6,919	9,216	7,226	10,678	-4.4	-15.9
Rice	28,924	26,179	30,679	29,748	-6.1	-13.6
Fruits and vegetables	19,499	20,435	20,582	22,854	-5.6	-11.8
Oil seeds	2,003	1,836	2,082	2,011	-3.9	-9.5
Roots and tubers	13,058	14,118	13,227	14,601	-1.3	-3.4

Source: IFPRI 2017 (model results provided by authors).

28. **The IMPACT model also predicts an increase in agricultural commodity prices due to climate change-induced output declines (Table 2).** The analysis projects that world prices for agricultural commodities increase, taking into account global changes in supply and demand, with and without climate change. FAO data suggest that changes in physical output and value due to climate change will cause prices to rise significantly due to climate change-induced output declines. For Vietnam, prices are projected to rise because of climate change by between 7 percent for fruits and vegetables and 29 percent for maize by 2030 and by 14 percent for fruits and vegetables, 54 percent for maize, and 19 percent for rice by 2050.

Table 2: Estimated agricultural commodity price increases in Vietnam by 2030 and 2050 (US\$/MT)

	Climate change		No climate change		Percent change	
	2030	2050	2030	2050	2030	2050
Maize	215	301	167	195	22.3	35.2
Rice	455	567	410	457	9.9	19.4
Fruits and vegetables	1,086	1,311	1,013	1,145	6.7	12.7
Oil seeds	575	669	500	511	13.0	23.6
Roots and tubers	434	516	388	425	10.6	17.6

Source: IFPRI 2017 (model results provided by authors).

AGRICULTURE AND RICE SECTOR EMISSIONS

29. **The agriculture sector is the second highest contributor to GHG emissions in Vietnam at about 19 percent of total emissions in 2020, with an estimated 104.5 million tCO₂e (BAU projection based on the 2014 emission level), almost triple the emission level in 2000.**¹⁵ Rice contributes about 48 percent of agricultural emissions, followed by enteric fermentation in livestock production (15.3 percent), management of synthetic fertilizer application (12.9 percent), manure management (9.5 percent), and others (Appendix 1, Figures A1.8 and A1.9). A unique feature of agricultural emissions is that over 70 percent of the GHG

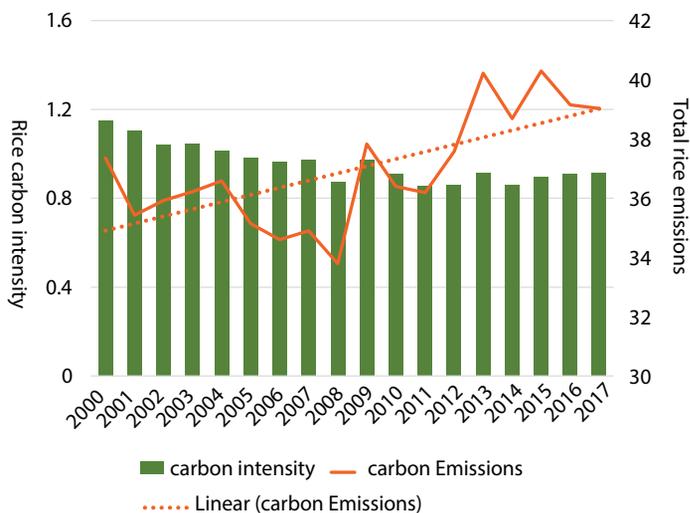
¹⁵ This projected emission level is from the GOV's NDC submission which is much higher than the 70.99 million tCO₂e reported by the FAO and World Resources Institute (WRI). This is because 104.5 million tCO₂e is a BAU projection for 2020 using the 2014 actual emission level (89.8 million tCO₂e, which is the same as the FAO agriculture emission level for Vietnam for 2014). The 2020 projection for Vietnam was developed based on the medium economic development scenario with assumptions on all parameters that affect emissions in agriculture including activity levels and production of rice, livestock, other crops, forest, and forest land use for 2020–2030. The procedures for the estimation of the national GHG inventory considered all the relevant factors such as activity definition, emission factors, and global warming potential aligned with the Intergovernmental Panel on Climate Change (IPCC) Guidelines (2006) for the estimation of the national GHG inventory.

emissions are composed of methane and nitrous oxide. Methane and nitrous oxide are more potent than carbon dioxide in causing global warming, but they both are short-lived, and so reducing them will have a faster and more powerful impact in reducing global warming. Agricultural emissions are expected to continue to rise given an increase in the demand for food from growing populations.

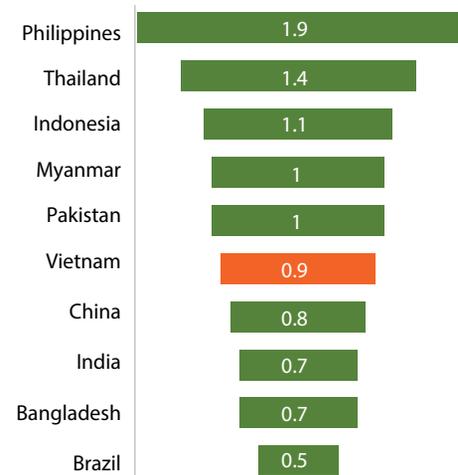
30. Rice GHG emissions have been steadily increasing in Vietnam. The FAO estimates that carbon emissions from rice have been above 35 million tons since 2000. From 2008 to 2017, emissions increased to nearly 40 million tCO₂e (Figure 6). The 2020 estimate of 44 million tCO₂e shows that this trend continues. This sharp rise in emissions may be due to both the increase in paddy output in excess of 43 million tons and the relatively high carbon intensity, estimated at about 0.9 kg of CO₂e per kg of paddy between 2010 and 2017 with an increasing trend since 2016. The increased intensity is likely due to the increased intensification in rice production. Increased water use (3,000–5,000 liters of water per kilogram of rice) and increased application of nitrogen, phosphorus, and potassium (NPK) fertilizers (estimated at about 400 kg per ha) are some of the reasons for the increased carbon intensity in rice production in Vietnam. Other reasons are explained in paragraphs 33–40.

Figure 6: Carbon emissions from rice

(a) Vietnam's paddy carbon emissions (tCO₂e) and intensity (kg CO₂e/kg of paddy - left axis)



(b) Carbon intensity (tCO₂e per ton of rice)



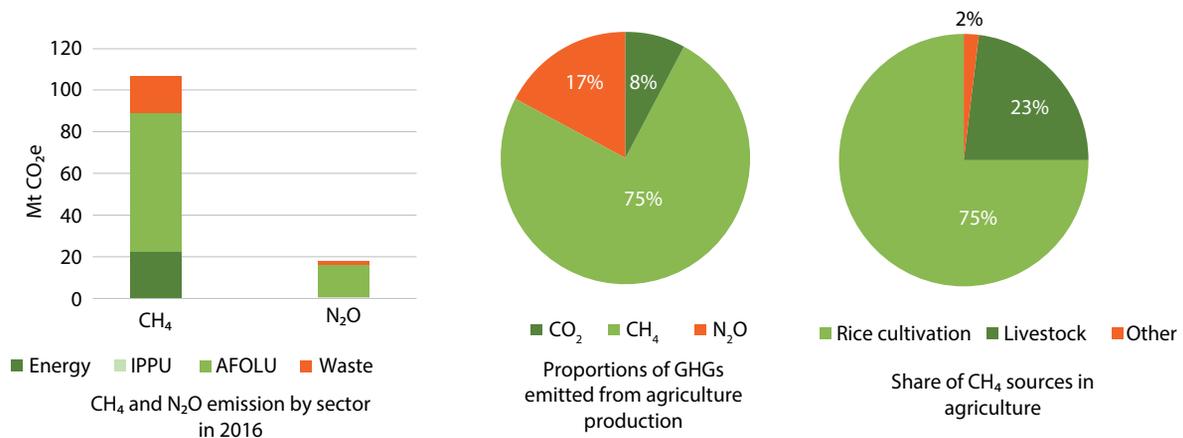
Source: FAO estimates (FAOSTAT 2020, <http://www.fao.org/faostat/en/#data>).

31. **Rice also accounts for about 75 percent of Vietnam's agricultural methane emissions (Figure 7).**¹⁶ It is grown in flooded conditions, such that the water blocks oxygen from penetrating the soil, creating ideal conditions for bacteria to thrive on decomposing organic matter, mainly rice straw residue, and release methane (Earth Security Group 2019). Poor absorption by the rice plants of nitrogen-based fertilizers, which are often overused by farmers, leads to nitrous oxide emissions. World Bank estimates indicate that in China and India, every ton of rice produced emits methane equivalent to 0.7 tCO₂e. This value is 1 tCO₂e in Pakistan and 1.5 tCO₂e in Thailand. Vietnam's methane emissions are above those of China and India, estimated at 0.9 tCO₂e.

16 The three major GHGs are carbon dioxide, nitrous oxide, and methane.

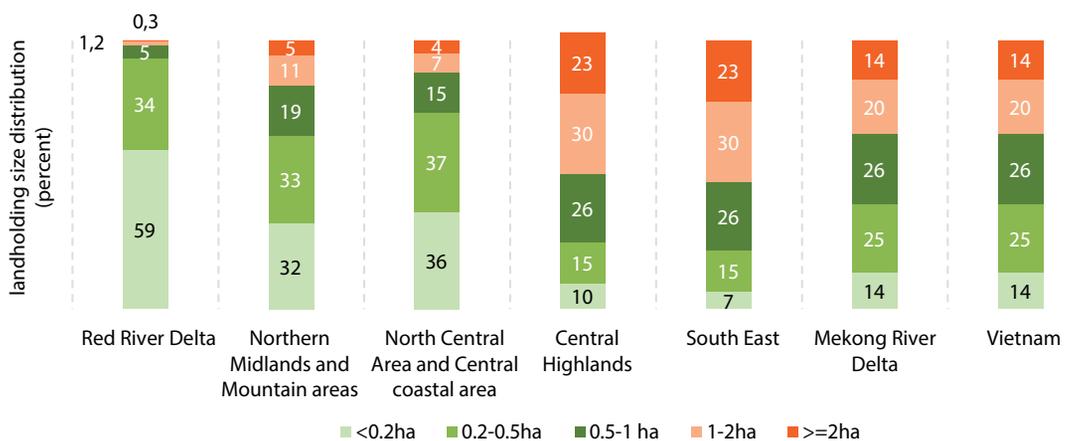
32. **Five key drivers increase GHG emissions in Vietnam’s rice production.** These are discussed in the following paragraphs: (a) unsustainable agricultural intensification and forest clearing, (b) high fertilizer application rates, (c) high levels of water use for irrigation, (d) improper management of rice residues such as rice straw and husks, and (e) poor energy use and efficiency in agriculture. Each of these drivers is essential to address as part of the LCT for rice.

Figure 7: Vietnam’s methane emissions from rice¹⁷



33. **Unsustainable agricultural intensification and forest clearing for agricultural expansion are two of the key drivers of the increased agricultural emissions in Vietnam.** Land use intensity is high, with rice yields above the mean level for Asia and an average of two to three rice crops per year. Vietnam’s agricultural land holding is among the most fragmented in the Southeast Asia region, and over 65 percent of farmers have less than 1 ha (Figure 8). Farmers grow several crops per year on their small farms to produce enough output. This means that land is continually producing without any fallow periods. There is high pressure to develop land and convert marginal lands previously seen as unsuitable for agriculture. This situation contributes to deforestation, forest degradation, and over intensive land use, which in turn lead to greater soil erosion, land degradation, and reduced soil fertility.

Figure 8: Landholding size distribution by region in percentage of farm sizes by land category, 2018



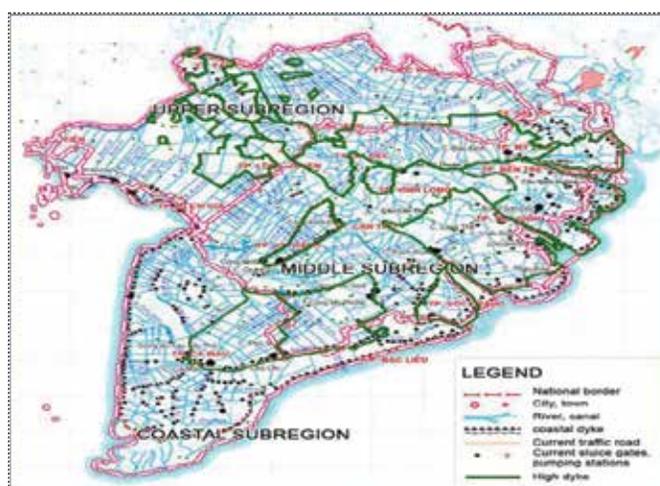
Source: Estimates based on the 2018 VHLSS data.

17 MONRE (Ministry of Natural Resources and Environment), 2020.

34. **Very high fertilizer application is another key factor.** Vietnam's rice yields are substantial, but this is due to very high application rates of fertilizers and pesticides relative to other countries in the region. Average paddy yields have reached 6 tons per ha, compared with average yields of 5.2 and 3.8 tons per ha in Indonesia and the Philippines, respectively. Yet Vietnam's rice yield growth has been slowing. Rice yield grew at an average rate of 3.1 percent per year from 1990 to 1995, 2.9 percent from 1996 to 2005, 1.6 percent from 2006 to 2013, and about 1.0 percent from 2015 to 2020. Fertilizer (NPK) application rates in Vietnam are among the highest in East Asia, slightly ahead of China, with average NPK application estimated at over 400 kg per ha (Appendix 1, Figure A1.10).¹⁸ The slowing of overall yield growth while input application remains high indicates that yield growth has plateaued with current rice technologies. Any further increase in input application results in a negative marginal return and an increase in GHG emissions.
35. **Vietnam's water use for irrigation is high relative to other countries in the region.** Vietnam's irrigated rice area, as a percentage of total arable land, was estimated at more than 65 percent in 2018 (Appendix 1, Figure A1.10), the highest in the region—almost on par with China. Rice is highly water intensive. It takes 3,000–5,000 liters of water to produce a single kilogram of rice, more than any other staple crop. In all, rice receives 34–43 percent of the world's irrigation water and 24–30 percent of its developed freshwater resources. In Vietnam, the high water intensity of rice cultivation, coupled with dwindling freshwater resources in the MKD and other rice-growing areas, represents a serious obstacle to expanding rice cultivation or even to maintaining current production levels. Moreover, incentives for using water more efficiently in rice production are limited by government policies prohibiting fee collection for irrigation water or its delivery. Competition for water is also increasing due to growing demand from domestic consumption in cities and from industry. Figure 9 shows the extensive irrigation canal system in the MKD, which mostly provides irrigation water for rice production. As freshwater becomes scarce, its inefficient use in rice reduces its productivity while also increasing GHG emissions.

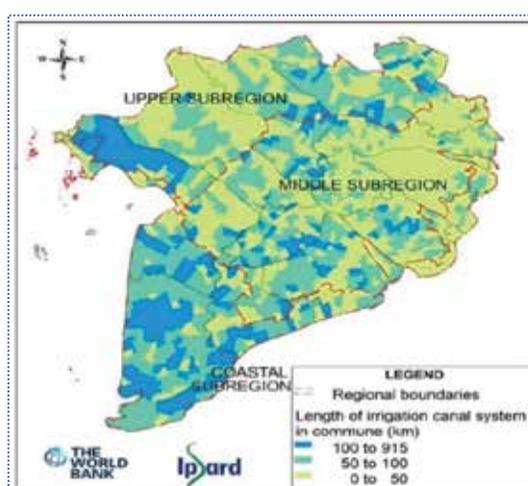
Figure 9: Extensive irrigation system in the MKD subregions

(a) Dike and sluice gate system



Source: Authors' illustration based on Southern Institute of Water Resources Research (2013).

(b) Irrigation canal length



Source: Authors' calculation based on AgroCensus (2016).

18 Source for Figures 11 and 12: World Bank staff estimates based on FAOSTAT 2020 data (<http://www.fao.org/faostat/en/#data>).

36. **Rice residues are often improperly managed in Vietnam.** Rice farmers across the world typically either leave these residues, such as rice straw and husks, to be submerged in the paddy fields, where they decompose and release methane, or burn them, thereby releasing carbon dioxide and soot. In Vietnam's MKD, at certain times of the year, up to 98 percent of rice farming residues are burned. Surveys of rice farmers in Thailand find that the main reason they choose to burn rice straw is the short turnaround between harvesting one crop and planting the next, which makes burning the quickest way to prepare the land for the next crop. The same incentives drive many farmers in Vietnam to also burn the residues. The practice of in-field straw burning results in GHGs of 0.7–4.51 g of CH₄ and 0.019–0.069 g of N₂O per kg of rice straw burned. Emissions from in-field rice straw burning also have serious negative consequences for human health from suspended particulate matter (PM_{2.5} and PM₁₀), polluting the air with toxic gases (Gadde et al. 2009).
37. **Emissions from rice are also caused by inefficient milling, waste, and losses from the rice processing system.** With the total paddy output of about 43 million tons, Vietnam's milled rice output is 27.1 million tons per year according to the report prepared by Vo 2021 for the Global Agricultural Information Network (GRAIN) of the United States Department of Agriculture (USDA), which translates to a milling recovery of about 62.5 percent (Appendix 1, Figure A1.11). This means that for every 100 kg of paddy, only 62.5 kg of milled rice is recovered. This results from the practice of milling rice twice, first as wet paddy at the farm then at government mills after drying. This practice is due to the lack of adequate drying facilities at the farm level. Modern milling systems can achieve 70 percent milling recovery. Thus, modernizing the milling system in Vietnam can result in significant reductions in losses and waste in the rice system.
38. **Inefficient and nonrenewable energy use in agriculture, including in rice production, contributes to the emissions.** Agriculture's preproduction and post-harvest activities consume energy and generate GHG emissions, in addition to direct GHG emissions from agricultural production activities. Agricultural activities such as cultivation and harvesting, planting, weeding, seeding, irrigation, food processing, input manufacturing, transportation, storage, food wholesale, retailing, and catering all use energy in the form of diesel, gasoline, coal, and electricity. Estimates of energy intensity-related emissions in agriculture have been on the increase from around 1.5 million tCO₂e in 2000 to slightly more than 5 million tCO₂e in 2018. Estimates also show an increase in the use of nonrenewable fossil fuels, including coal (Appendix 1, Figure A1.12). The use of renewable energy sources such as solar remains limited in agriculture.
39. **Rice is the major source of calories for about 97 million Vietnamese and is the main source of livelihood for more than 20 million people in the country's main rice-growing areas, the Mekong and Red River Deltas.** Globally, rice is important for food security and is a major source of livelihoods for about 150 million smallholder farmers worldwide, who are mostly poor and who grow rice in small plots of land measuring less than 1 ha. Because of its cultural, social, and economic importance in the country, such that rice production will remain a priority, promoting the transition to low-carbon rice production would be critical moving forward, and technical solutions exist to do this.
40. **According to IRRI, many technologies and practices enable higher rice production while emitting less GHGs.** For example, climate-smart rice planting (CSRP) is a type of integrated rice cropping system that involves using climate-resilient crop cultivars and new tillage practices to relieve waterlogging, increasing oxygen in the topsoil, and using energy-saving tillage-sowing-fertilizing machinery and rotation with a cover crop. There are breeding efforts to produce new rice varieties that reduce emissions (World Bank 2020a). There are also many other promising agronomic practices, including machine transplanting, rice straw management options, dry-seeded rice, compact rice milling, and zero tillage. These are discussed in Appendix 2.



CHAPTER 3

PATHWAYS TO A LOW-CARBON TRANSITION IN THE RICE SECTOR

Key messages

- Both agronomic and digital options have been technically and economically proven to offer feasible no-regret pathways to promote low-carbon rice.
- Some options have been piloted in Vietnam and have potential for significant upscaling at the farm level.
- Scaling up the options with the most economic benefits can enable Vietnam to achieve higher emission reduction targets most efficiently.
- Farm-level, partial, and economywide analyses show that a combination of two approaches—promoting water management through alternate wetting and drying (AWD) system of irrigation and optimal application of inputs through One Must Five Reductions (1M5R) practices—will maintain or increase yields and farmer incomes while also reducing GHG emissions.
- Significant GHG reductions are possible if AWD and 1M5R are widely and quickly scaled up.
- Combining a carbon tax and sectoral strategies results in better GHG emission reduction and economic growth.
- Securing international support to reach the medium and high investment scenarios would help Vietnam reach the highest emission reductions.

41. **Many technologies have been technically proven to help with the transition to low-carbon rice.** A few are economically feasible for scaling up at the farm level in Vietnam and have been applied in Vietnam, albeit on a small scale. GHG mitigation options specific to rice production in the MKD have been established through field trials implemented by MARD through projects supported by partners, including technical assistance provided by IRRI.
42. **Most of the transition options offer both mitigation advantages in terms of GHG emission reduction and adaptation benefits in the form of resilience.** Many are regarded as high-priority options for implementing the NDCs in the MKD region according to Decision 7028/BNN-KHCN on August 26, 2016, by MARD.
43. **In its updated 2021 NDC, Vietnam mentions two different rice management methods and a water management technique.** This report specifically examines one rice input management method, 1M5R,¹⁹ and the AWD system water management technique. The AWD system of irrigation helps adapt to climate change and reduce emissions through the more regulated application of water in the paddy fields. 1M5R improves rice production through what is known in Vietnam as 'One Must', namely the use of certificated seed, and 'Five Reductions', namely reducing the amount of seed sown; the amount of pesticide, N-fertilizer, and irrigation water used; and post-harvest losses.²⁰ These two pathways are prioritized because they represent no-regret options because they result in higher GHG emission reductions per US dollar spent relative to other options. They are also the two technology options which are the most familiar to farmers, based on pilot demonstrations conducted in Vietnam's rice systems during the past decade or longer.
44. **The Vietnam Sustainable Agricultural Transformation Project (VNSAT) supported AWD and 1M5R and demonstrated the farm-level economic and financial viability of both practices.** Funded by the International Development Association (IDA), the project assisted over 240,000 rice farmers in adopting AWD and 1M5R over 163,418 ha. Rice farmers reduced input levels (that is, pesticide and fertilizer applications, water uses, and post-harvest losses) by 20–30 percent, increased rice productivity by 3–4 percent, raised

19 The other rice management method is Three Reductions, Three Gains (3R3G).

20 MARD places emphasis on profitability and food security for farmers as the first priority rather than GHG reduction. Profitability ensures economic sustainability of mitigation actions especially for farmers, while the slightest burden or lower yield will prevent them from adopting measures even if marginal abatement costs for measures at the national level are acceptable.

the sale price by 5–10 percent, and boosted net profits by 28 percent, mainly due to reduced production costs. The project reduced GHG emissions by nearly 1.5 million tCO₂e. Supporting sustainable rice farming practices required an investment of around US\$400 per ha to finance additional small-scale infrastructure and equipment at the cooperative level (that is, driers, storage, fixing sluiceways, farm paths to facilitate harvesting, and so on).

AWD SYSTEM OF IRRIGATION

45. **AWD is an irrigation technique in which water is applied to allow for intermittent drainage of the paddy field.** This contrasts with the conventional irrigation practice of continuous flooding of the field. AWD allows intermittent drying during certain stages of the rice growing cycle, because the roots of the rice plants are still adequately supplied with water due to the initial flooding.²¹ The number of days in which the field is allowed to be ‘non-flooded’ before irrigation is applied can vary from 1 day to more than 10 days. With increasing water scarcity becoming a key concern for Asian rice producers in the dry season, applying AWD on a large scale could conserve freshwater resources and either extend the growing cycle during the dry season or expand rice production areas. The farmer adoption of AWD to date, however, is low due to initial investment costs.

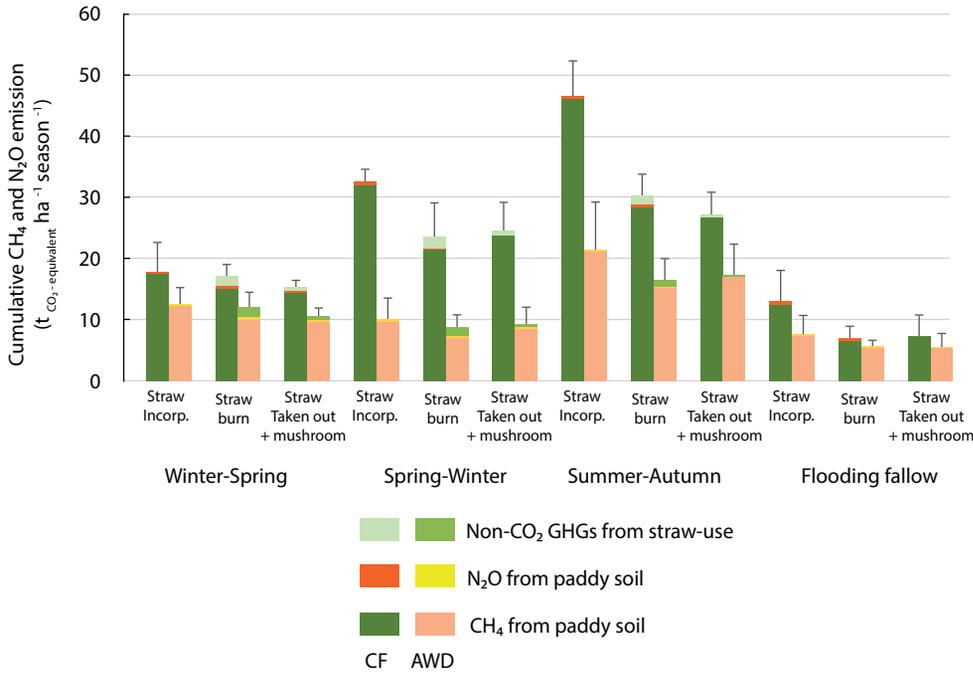
Emission reductions from AWD systems

46. **Research conducted in many countries including in Vietnam shows that the AWD system of rice irrigation can reduce emissions without affecting the rice yield, relative to continuous flooding.** The AWD technique first began in China and India in the 1980s and 1990s (Mushtaq et al. 2006). It is considered as a water-smart, weather-smart, and carbon-smart technique in rice production (Wassmann et al. 2019). This system is being applied, at various levels, in many Asian countries, including China, Bangladesh, India, and Vietnam, where it is seen to reduce water consumption by 30–35 percent (Song et al. 2021).
47. **In Vietnam, research conducted through field trials from 2012 to 2016 shows that the cumulative methane emissions from rice in continuously flooded (CF) fields are higher than in fields where AWD is applied (Figure 10).** Analysis conducted by Le Toan et al. (2021) with support from the French Development Agency (*Agence Française de Développement*, AFD) shows that methane emissions are greatly reduced by AWD for the spring-summer rice and summer-autumn rice, when the emissions are highest. The reduction is more moderate for the winter-spring dry season and the fallow period. Results from this analysis also show that incorporation of straw has the highest emission following the decomposition of the organic matter. However, research conducted by the scientists under the Environmental Defense Fund (EDF) has found an inverse correlation between methane and nitrous oxide emissions from rice farming, implying that while water management techniques such as AWD reduce methane emissions, they also tend to increase nitrous oxide emissions. Thus, to reduce both methane and nitrous oxide, it is important to combine AWD and 1M5R.²²

21 Under the AWD practice, rice field is drained periodically to enhance aeration of the soil, inhibiting methane-producing bacteria, thereby reducing methane emissions. The water depth of the rice field is monitored using a perforated water tube ‘pani-pipe’. At one to two weeks after transplanting, the field is drained until the water level reaches 15 cm below the soil surface. Then, the field is re-flooded to a depth of around 5 cm before re-draining. This procedure is continued throughout the cropping season except for one week before and one week after flowering. The practice reduces the number of irrigations significantly, thereby lowering irrigation water consumption up to 30 percent, increasing net return for farmers by promoting more effective tillering and strong root growth of rice plants, and reducing fuel consumption for pumping water by 30 liters per ha (MONRE 2020).

22 According to a global analysis released by EDF, methane and nitrous oxide emissions from rice farms could have the same long-term warming impact as about 600 coal plants (1,900 MMT per year CO₂e/100). In the short term, this warming impact could be as much as 1,200 average-size coal power plants (3,600 million tCO₂e per year) because nitrous oxide lasts many more decades in the atmosphere than methane (EDF 2018).

Figure 10: Impact of AWD on methane emissions

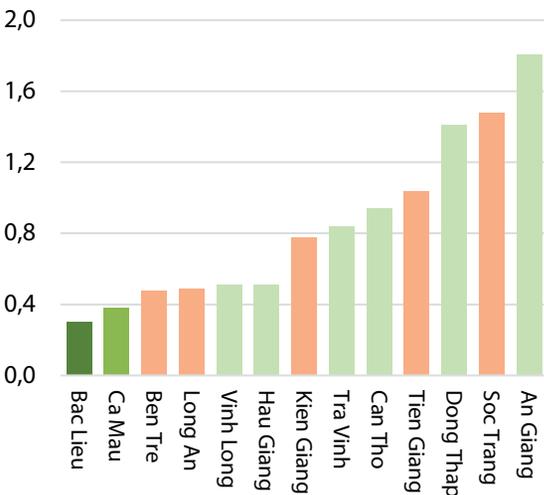


Source: Le Toan et al. 2021.

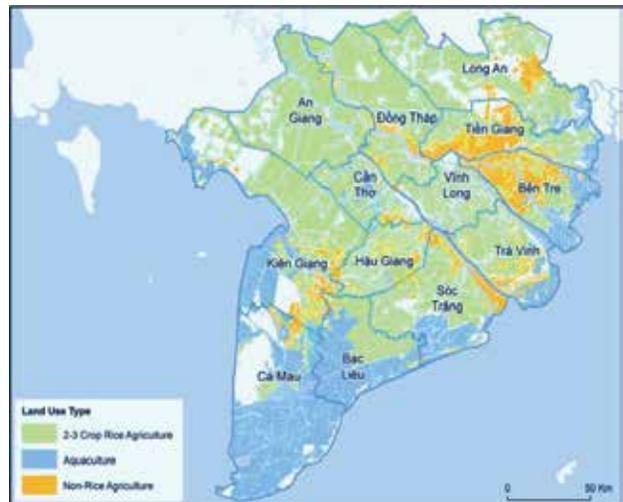
48. **Field trials demonstrate that methane emission reductions are possible.** The field trials conducted by IRRI through a World Bank-funded project, VNSAT, found that the potential GHG emission reduction was estimated at 10.97 million tCO₂e per year by 2030, and the potential emission reductions are higher in the key rice-producing provinces of the MKD (Figure 11).

Figure 11: Potential GHG emission reductions in million tCO₂e from AWD in the MKD until 2030

Potential emission reductions by province (million tCO₂e)



Map of the MKD



Source: Based on data from Tran et al. (2019).

Economic benefits of the AWD system

49. **Field trials conducted by IRRI under the VNSAT indicate that AWD is financially viable at the farm level.** The field trials found that the average net financial benefit to the farmer of applying AWD was estimated at VND 27.53 million per ha, compared to normal rice production practice without AWD at VND 4.43 million per ha. The analysis assumes that the initial irrigation capital investment costs of about US\$1.03 billion to retrofit the system for water control are fully borne by the government.²³
50. **AWD is also economically beneficial to society as a whole while reducing emissions.** If 1.9 million ha of rice land is cultivated according to the AWD method, the net economic benefits are estimated to be VND 52,960 billion (approximately US\$2.3 billion) per year by 2030. This represents an addition of VND 8,540 billion (US\$371.36 million) compared to conventional rice production methods, due to increased revenue and reduced costs in terms of land preparation, seed sowing, irrigation water, and labor (based on assumptions of no previous use of AWD by farmers and using a 2016 conversion rate). The potential GHG emission reduction was estimated at 10.97 million tCO₂e per year cumulatively by 2030 (Table 3).²⁴

Table 3: Estimated impact analysis of a low-carbon rice investment plan in MKD for AWD

Province	Potential GHG reduction by 2030 (million tCO ₂ e)	Net benefit estimates		Difference with conventional flooding irrigation per year	
		VND, billions	US\$, millions	VND, billions	US\$, millions
Long An	0.49	2,378	103.4	383.5	16.7
Tien Giang	1.04	5,031	218.7	811.3	35.3
Ben Tre	0.48	2,310	100.5	372.6	16.2
Tra Vinh	0.84	4,078	177.3	657.6	28.6
Vinh Long	0.51	2,450	106.5	395.1	17.2
Dong Thap	1.41	6,800	295.7	1,096.6	47.7
An Giang	1.81	8,733	379.7	1,408.3	61.2
Kien Giang	0.78	3,751	163.1	605.0	26.3
Can Tho	0.94	4,553	198.0	734.3	31.9
Hau Giang	0.51	2,459	106.9	396.6	17.2
Soc Trang	1.48	7,143	310.6	1,152.0	50.1
Bac Lieu	0.30	1,463	63.6	236.0	10.3
Ca Mau	0.38	1,812	78.8	292.2	12.7
Total	10.97	52,962	2,302.7	8,541.20	371.36

Source: Tran et al. 2019.

51. **There are, however, significant variations in GHG reduction from AWD reported from different pilot projects in Vietnam over the past years.** Many of the variations are due to the differences across technologies applied and factors which include, but are not limited to, weather, seasonal patterns, and locations as well as measurement challenges (Vo et al. 2020). For example, less encouraging results have been reported by the AgResults Vietnam GHG Emissions Reduction Challenge Project supported by the SNV Netherlands Development Organization from 2017 to 2020 to develop, test, and scale up innovative technologies, tools, and approaches to increase yields and reduce GHG emissions in rice production. Their results showed that measurement of GHG emissions from rice production was highly uncertain, and in

23 Estimates made by IRRI suggest that this should cover 1.9 million ha in the Mekong and Red River Deltas.

24 Assuming a total of 1.9 million ha of rice would be brought under AWD application by 2030.

some cases the results measured showed negligible emission reductions (Geyer, Greif, and Mainville 2022). However, a recent study by Singleton, Trinh, and Tran (2022) shows that key factors that lead to differences between GHG emissions in the MKD and the Red River Delta include season (different temperature and water regimes) and soil type. Acidic and heavy clay soils have higher GHG emissions than saline and loamy soils. Also, carbon emissions are higher in soils with high organic content than poor clay soils. Furthermore, water regimes (deep flooding has higher emissions; good drainage to dry the root zone has lower emissions), incorporation of rice straw into the soil before planting, and the application of manure to the soil increase emissions. Also, the variation in the topography of a field is closely related to high variation and high uncertainty in GHG emissions. Under longer-term projects, such as the VNSAT, the implementation of AWD has been supported by intensive training of the farmers as well as continuous technical assistance by IRRI in terms of both the application of the technology and the measurement of the GHG emission reductions.

ONE MUST FIVE REDUCTIONS

52. **1M5R is another no-regret set of technologies that improves on-farm input efficiency by farmers, thus reducing GHG emissions.** 1M5R is an agronomic package aimed at reducing farmers' application of fertilizers and other inputs in the rice production systems. 1M5R means using certified seeds and reducing the quantity of seed, chemical fertilizer, pesticide, water use, and post-harvest losses. It was developed by IRRI and has been applied in Vietnam since 2013.²⁵ The net income increases were achieved by boosting output and reducing the use of inputs such as seed, fertilizer, pesticides, and labor as well as reducing post-harvest losses. GHG emissions were reduced by 20–30 percent compared to the BAU scenario (Table 4).

Table 4: Technical benefits of 1M5R compared to farmer practices (%)

	Direct seeded rice		Drum seeders		Mechanical transplanters	
Winter-spring crop						
Nitrogen use efficiency	-24.5	(0.23)	-25.1	(0.20)	3.5	(0.26)
Grain yield	10.1	(0.01)	10.1	(0.01)	11.3	(0.00)
Energy efficiency	7.8	(0.22)	6.8	(0.16)	10.6	(0.14)
Reduced GHG emissions	26.6	(8.28)	26.7	(8.20)	32.0	(7.87)
Summer-autumn crop						
Nitrogen-use efficiency	18.8	(0.10)	12.9	(0.11)	18.8	(0.12)
Grain yield	2.3	(0.00)	-4.0	(0.00)	5.1	(0.00)
Energy efficiency	1.3	(0.11)	-7.9	(0.16)	4.3	(0.14)
Reduced GHG emissions	29.9	(7.09)	29.8	(7.06)	30.2	(7.03)

Source: IRRI 2020.

Note: Net benefits (percent) of the VNSAT-1M5R treatments compared with farmer practices.

53. **Results from the ACP implemented by MARD until 2013 also provided support for the 1M5R agronomic practice in rice production.** The ACP covered about 42,600 ha in several provinces in the MKD. Data collected for the first 2013 summer-autumn crop showed that in the 1M5R pilot, seed use was reduced by 29–50 percent compared to the control group, inorganic fertilizer was reduced by 22–50 percent, water use was reduced by 30–50 percent, and the number of pesticide applications was reduced by 20–33 percent. Consequently, production costs declined by VND 4 million per ha (22 percent), rice yields increased by 5.2–

²⁵ +Mostly under projects implemented by MARD but supported by the World Bank such as the Agriculture Competitiveness Project (ACP) and VNSAT.

7.9 percent, and profits increased by 29–67 percent. Similar results were found for the second 2013 autumn-winter crop.

54. **Based on field trials, the 1M5R option of fertilizer and other input management in rice has proven to be both financially and economically viable.** For example, field demonstrations of 1M5R in rice production in Can Tho Province across two seasons in 2018–2019 under the VNSAT resulted in several benefits, compared to current farmer practices. Mean grain yield increased by 10 percent in winter-spring (the third crop) and 2 percent in summer-autumn (the first crop), with net income increasing by 7 percent in winter-spring and 17 percent in summer-autumn. The net income increases were achieved through an increase in output combined with significant reductions in the use of, and expenses on, inputs such as seed, fertilizer, pesticides, and labor. GHG emissions were reduced by 26.6 percent in winter-spring and 29.9 percent in summer-autumn. Detailed results from the field trial are shown in Table 5.

Table 5: Net economic benefits of 1M5R compared to traditional farmer practices (%)

	Direct seeded rice		Drum seeders		Mechanical transplanters	
Winter-spring crop						
Labor productivity	9.4	(0.39)	11.8	(0.34)	6.7	(0.35)
Grain yield	10.1	(0.01)	10.1	(0.01)	11.3	(0.00)
Energy efficiency	7.8	(0.22)	6.8	(0.16)	10.6	(0.14)
Reduced GHG emissions	26.6	(8.28)	26.7	(8.20)	32.0	(7.87)
Net income	7.0	(1.61)	8.7	(1.16)	13.2	(1.20)
Summer-autumn crop						
Nitrogen use efficiency	18.8	(0.10)	12.9	(0.11)	18.8	(0.12)
Grain yield	2.3	(0.00)	-4.0	(0.00)	5.1	(0.00)
Energy efficiency	1.3	(0.11)	-7.9	(0.16)	4.3	(0.14)
Reduced GHG emissions	29.9	(7.09)	29.8	(7.06)	30.2	(7.03)
Net income	17.6	(0.97)	6.9	(7.06)	9.0	(1.35)

Source: IRRI 2020.

Note: Net benefits (percent) of the VNSAT-1M5R treatments compared with farmer practices.

USE OF DIGITAL TECHNOLOGIES

55. **In Vietnam, the use of some of these digital tools along with the agronomic technologies such as AWD and 1M5R has added benefits.** Using the internet of things (IoT)—which includes water sensors to help farmers better decide on optimal amount of water to apply—reduces water use by up to 42 percent compared to manually flooding rice fields, cuts production costs by up to 22 percent, and increases rice yield by 24 percent (Choudhary and Fock 2020). These smart irrigation systems reduce GHG emissions by 60–70 percent compared to the manual system of irrigation (equivalent to 4–6 tCO₂e per ha per crop season). Figure A2.1 in Appendix 2 shows the value of digital technologies in rice and coffee production in Vietnam. Research conducted elsewhere an IoT-based system integrates laser sensors for precise water level measurement for automation of the AWD technique for different sizes of fields. Irrigation automation is further upgradable by utilizing various sensors, wireless links, and internet infrastructure due to the increasing availability and decreasing cost of these technologies.

Cost-effectiveness of LCT options (partial equilibrium analysis)

56. **Evidence from partial equilibrium analysis indicates that most of the available mitigation options including AWD and 1M5R are cost-effective, but they require significant initial investment.** For AWD or 1M5R in rice areas with poor irrigation infrastructure, with an average direct cost of about US\$95 per tCO₂e, the total investment outlay will be about US\$3.1 billion by 2030 (Table 6). This results in higher impact in terms of GHG emission reduction, estimated at 32.6 million tCO₂e—which is equal to the higher target set under the NDC. The costs vary depending on the emission reduction targets as well as the state of irrigation infrastructure (the full range of costs estimated per emission reduction scenario is presented in Table A2.1 in Appendix 2). The analysis shows that some of the options have a negative net cost because though adopting the measures benefit farmers, this does not mean they can be implemented without any initial up-front investments (see Table 6). These mitigation options include converting from rice to shrimp, rice-aquaculture, shifting from rice to upland crops such as fruits and vegetables, and improved rice straw and residues management.²⁶ These actions also support adaptation. Except for AWD and 1M5R, most other options achieve significant emission reduction only if many are adopted together as a package and used at the same time.

Table 6: Potential mitigation and cost-effectiveness of available GHG mitigation options in rice at farm level

GHG mitigation options/practices	Mitigation Potential (million tCO ₂ e)	Total Cost (US\$, millions)	Cost-effectiveness (US\$/tCO ₂ e)
AWD and 1M5R in rice areas with medium irrigation infrastructure	25.70	1,670.5	65.0
AWD and 1M5R in rice areas with poor irrigation infrastructure	32.60	3,093.7	94.9
Moving from rice to shrimp farming	6.50	-544.3	-83.3
Converting rice areas to rice-aquaculture	7.20	-293.2	-40.7
AWD in Mekong (CR)	37.89	-833.5	-22.0
AWD in Red River Delta	12.67	-213.6	-16.9
Converting from rice to upland crops	7.90	-0.8	-0.1
Improved rice straw management	5.97	76.6	12.2

Sources: Escobar et al. 2019.

Assessing long-term climate change mitigation potentials using a computable general equilibrium analysis

57. **This report utilizes a computable general equilibrium (CGE) model to simulate a selected set of options for sustainable rice production to assess their impact on carbon emissions in Vietnam (see the detailed model description in Appendix 3).** Four scenarios were examined: (a) reducing unfavorable land under rice production, as per the recent Decision No. 555/QĐ-BNN-TT, which sets a target of a 5 percent reduction in rice area by 2030; (b) reducing the fertilizer application rate, using optimal rates of application, that is, 20 percent less fertilizer application by 2030, as per the recommendations in 1M5R; (c) reducing the fertilizer application by 20 percent plus an assumed 4.5 percent increase in productivity to capture the efficiency gains from the optimal fertilizer application level; and (d) applying a carbon tax—which is gradually varied linearly from US\$1 to US\$10 (conservative), US\$40 (medium), or US\$90 (aggressive) by 2040. The assumptions for each of these simulations are presented in Table 7.

26 The benefits of AWD in terms of productivity were demonstrated in the discussion on adaptation.

Table 7: Situation analysis using the CGE framework

Simulation scenarios	Assumptions
Reducing unfavorable land under rice production	5% area reduction: Decision No. 555/QĐ-BNN-TT gives this as the approximate reduction target in 2030.
Reducing fertilizer application (1M5R)	20% fertilizer reduction assumes that 20% would be the 'average' target. The model assumes that this change is cost neutral; that is, the farmer spends the money saved from fertilizers for other intermediate inputs such as seed and labor-saving small machinery to maintain the yield.
Reducing fertilizer and productivity increase	20% fertilizer reduction plus an assumption of 4.5% productivity increase (to compensate for a productivity loss due to the model's functional form—constant elasticity of substitution). While the fertilizer application rate is reduced, it is assumed that other inputs and factors of production such as the use of improved certified seed gain productivity to keep production more or less the same. This is meant to show the effect of improving cost efficiency, increasing technology/know-how to raise productivity and net income.
Scenarios plus a carbon tax	Modeling assumes that carbon price will gradually increase linearly from US\$1 to US\$10 (conservative), US\$40 (medium), or US\$90 (aggressive) by 2040.

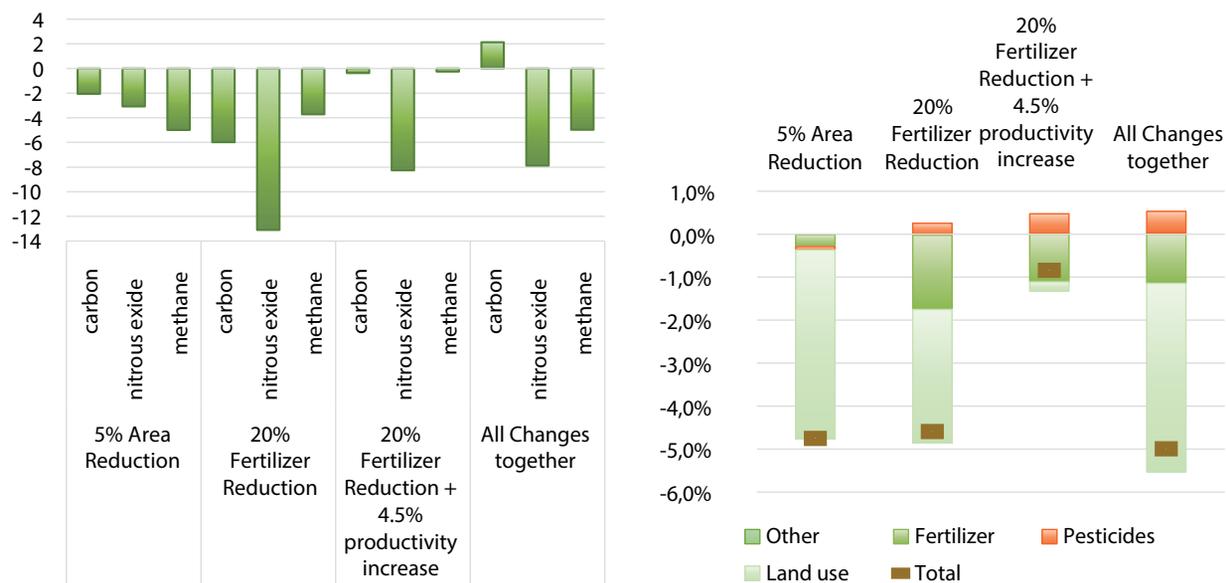
58. **The findings from the CGE modeling for each of the four simulations are shown in Figure 12.** Overall, the results from the modeling show that compared to the BAU, the above simulations (Table 7) are effective in reducing GHG emissions in rice production. The results from each simulation are discussed in more detail in the following sections.

Reducing unfavorable land under rice production

59. **Promoting adaptation by reducing unsuitable land under monoculture rice production reduces GHG emissions by up to 6 percent compared to the baseline or BAU scenario.** The results show that a 5 percent reduction in land under rice cultivation reduces carbon, nitrous oxide, and methane emissions by 2.06, 3.08, and 6 percent, respectively (Figure 12). Since methane makes up most of the emissions in rice production resulting from unsustainable land use, moving out of unsuitable land reduces methane emissions more than the other GHGs. A study conducted by the World Bank and IPSARD²⁷ showed that (a) replacing the unsuitable and unsustainable practice of producing two to three rice crops per year with low-carbon climate-smart cropping systems would help farmers adapt to the changing climate and environment and (b) promoting climate-smart, low-carbon technology options and practices in the remaining core rice areas to mitigate GHG emissions could help significantly reduce emissions. In the MKD, estimates suggest that about 760,000 ha of two-rice and three-rice cultivation areas in the MKD are no longer suitable due to the impact of climate change (for example, less water availability, increasing saltwater intrusion, and so on) and the changing environment. If such marginal areas of two to three rice crops would shift to other lower-carbon farming systems (that is, fruits and vegetables or aquaculture, with less GHG emissions), it would help cut down GHG emissions while also enabling farmers to increase their incomes.

27 World Bank and IPSARD 2020.

Figure 12: Impact of several simulations on GHG emission reductions



Source: Estimates based on the CGE modeling 2021.

Reducing fertilizer application rate through 1M5R

60. **Reducing the level of fertilizer application rates to optimal levels also cuts emissions, mainly carbon dioxide and nitrous oxide.** A 20 percent reduction in fertilizer application results in a 6, 13.1, and 3.7 percent reduction in carbon, nitrous oxide, and methane emissions from rice production, respectively, bringing the total CO₂e emissions from rice production down by about 5 percent. It is worth noting that using less fertilizer reduces CO₂e emissions. However, reducing rice-growing areas mainly lowers methane emissions. Reducing fertilizer use lowers nitrous oxide emissions significantly. This shows that rice sector emission reduction needs to be targeted in a comprehensive way, while considering the substitution effects of different inputs and factors of production.
61. **Overall, reducing both the rice cultivation area and the amount of fertilizer used will cut emissions by more than 5 percent per year by 2030 compared to the BAU scenario.** These results show that the biggest emission reductions are achieved when the technical options are coupled with reducing land under rice cultivation by considering the substitution possibilities in the production structure.²⁸

Use of the technical options plus a price instrument, namely a carbon tax

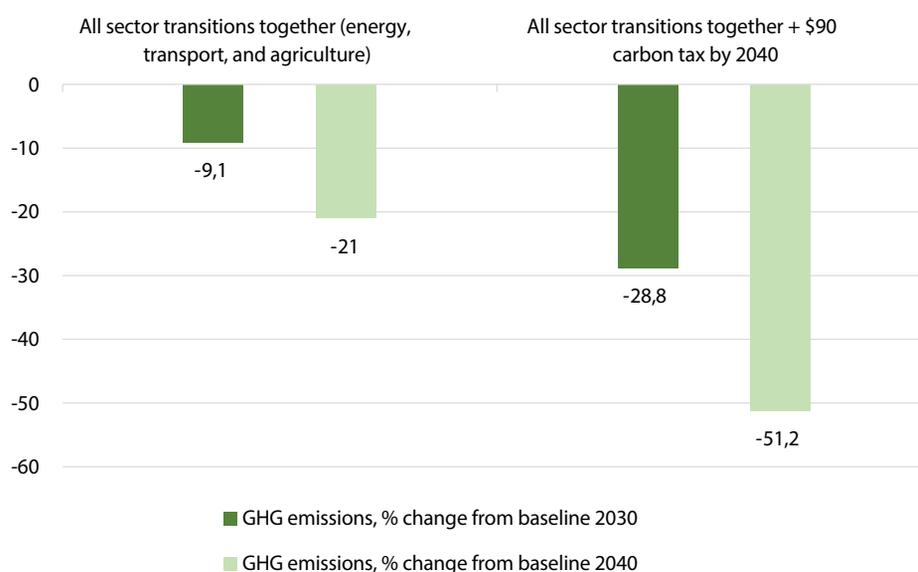
62. **The application of technical options alone will not be sufficient to achieve net-zero emissions.** A net-zero pathway would require applying complementary mitigating options across all key emission-intensive sectors, including a pricing instrument such as a carbon tax. The CGE model shows that the use of pricing instruments in all key emitting sectors could be the most effective way to curb GHG emissions over time

²⁸ For a complete analysis of emission reductions, agricultural water management scenarios need to be added to, for example, the impact of AWD on emission reductions. This requires making fundamental changes in the Social Accounting Matrix (SAM) to introduce irrigation water accounts, including the amount of water used in each agricultural activity and a shadow price for each, and the cost structure of irrigation water production. This will require more data and will probably be continued further into FY22.

rather than just using sectoral strategies alone. To achieve its commitment of reaching net-zero emissions (carbon neutrality) by 2050, the government will have to combine ambitious transitions in the highest emitting sectors (energy, transport, agriculture, and manufacturing) with carbon pricing. The existing small carbon tax—the so-called Environmental Protection Tax (EPT)—would need to reach US\$24 per tCO₂e in 2030 and gradually increase to US\$90 per tCO₂e in 2040. Such a combination of sectoral policies and carbon pricing appears necessary to put the economy on the trajectory toward net-zero emissions.²⁹ The tax will be paid only by the 18 most emitting sectors, including agriculture. The modeling includes reducing unsustainable carbon-intensive rice production by promoting AWD and lowering fertilizer application rates to optimal levels.³⁰

63. **Combining a carbon tax and sectoral strategies produces higher GHG emission reductions.** Without a carbon tax, emission reductions will reach 9.1 and 21 percent compared to the baseline by 2030 and 2040, respectively. With the carbon tax, emission reductions will reach 29 and 51 percent compared to the baseline by 2030 and 2040, respectively (Figure 13).

Figure 13: Effect of sectoral strategies coupled with a carbon tax on emissions and total GDP



Source: Estimates from the CGE model.

64. **In agriculture, these model results assume that the land market is fully functional and there are no structural constraints affecting farmers' ability to change land use.** Currently, Vietnam has restrictions that make it difficult for farmers to move land out of rice production; rice land is protected as part of the food security policy. For a price instrument such as the carbon tax to work efficiently, there is need to ensure that structural constraints affecting land use changes are eased.

²⁹ Vietnam has introduced the EPT to curb carbon emission in the country. This tax is levied on all products contributing to GHG emissions. It is however not being applied to crops such as rice. The current rate charged is very low, around US\$0.5 per tCO₂e on coal, by both regional and international standards. However, it is assumed that the government will be able to gradually increase the carbon tax to US\$24 per tCO₂e by 2030 and US\$90 per tCO₂e by 2040. There are lessons from other countries; for example, Mexico allows the use of clean energy certificates to reduce tax obligations, Colombia allows the use of REDD+ credits, and South Africa which plans to allow the use of certified emission reductions (CERs) could inform Vietnam's transition to use price instruments in its decarbonization agenda.

³⁰ Reducing unfavorable land under rice aligns with the recent decision released by MARD on January 26, 2021 (Decision Number 555/QĐ-BNN-TT) on Approving Scheme for Restructuring of Viet Nam's Rice Industry by 2025 and 2030, with the target rice land to ensure food security and rice exports being 3.6–3.7 million ha by 2025 and 3.5 million ha by 2030. Lowering of fertilizer application rates is based on the recommendations for scaling up the application of 1M5R together with the AWD system of rice irrigation.

65. **The cost of transition to low-carbon rice is quite high (Figure 14).** Considering the most practical (in terms of available technologies and farmers' familiarity) and cost-effective options (in terms of cost per tCO₂e mitigated), and *in view of the targets set under each of the scenarios defined in line with the NDC,*³¹ the investment cost estimates range from about US\$110 per ha for the low-case scenario, US\$515 per ha for medium-case scenario and about US\$3,890 per ha for the high-case or net-zero scenario by 2030. Applying the same unit costs per tCO₂e will result in investment costs estimates ranging from US\$226 per ha for the low-case scenario, US\$1,085 for the medium-case scenario and over US\$8,200 for the high-case or net-zero scenario by 2040.³² These estimates assume an average abatement cost of US\$30 per tCO₂e (Escobar et al. 2019). While these are estimates based on current assumptions, it is clear that the longer it takes to transition, the higher the costs will be. The range of investment costs varies significantly depending on the state of the existing irrigation infrastructure, with the highest cost in areas with the most dilapidated irrigation infrastructure requiring heavy capital investments. In the cost estimation, it is assumed that infrastructure costs comprise over 80 percent including estimated cost for land levelling.³³ Other components of the investment cost estimate include technical capacity strengthening (for operations and maintenance of irrigation system and farmers' adoption of appropriate practices; establishment of a measuring, reporting, and verification [MRV] system; and partnership building for all stakeholders including farmers and the private sector; see Figure 14). These other costs together account for less than 20 percent of the estimated investment costs. The methodology and key assumptions for the estimation of the transition costs are highlighted in Box 2.

31 As indicated in Chapter 1, Vietnam's NDC defines the scenarios as follows: (1) unconditional target of 6.8 million tCO₂e per year by 2030 using domestic resources, (2) conditional target of 32.6 million tCO₂e by 2030 assuming international support, and (3) net-zero level by 2050. For this report, scenario 1 is 'AgriLow', scenario 2 is 'AgriMed', and scenario 3 is 'AgriHigh'.

32 These costs are lower than those estimated by the government, which total over US\$22.2 billion to achieve net-zero emissions in agriculture by 2050. The government estimates are based on the assumption of heavy initial investments until 2030, amounting to over US\$14.5 billion (MONRE 2022).

33 Land leveling helps create a flat surface on the rice fields allowing irrigation water to reach every part of the field, thus reducing water runoff or logging. Modern laser technology is used to improve the leveling precision. According to IRRI, precision land leveling using a stationary laser plane leads to water savings (40–60 percent), increased yields 10–20 percent, and better weed control and can also be used for field consolidation for improved mechanization (<https://tinyurl.com/y6s4nmzx>).

Box 2: Estimation of the transition costs - Methodology and key assumptions

The cost parameters are derived from the marginal abatement cost curve (MACC) methodology, which is typically used to evaluate mitigation policies. An important reason for using the MACC methodology is that it helps overcome some of the conceptual and data limitations of the technical reports that underlie Vietnam's own NDC estimates. The cost estimates are obtained by multiplying the GHG emission reduction targets (in CO₂e) by an assumed level of marginal abatement cost (US\$/tCO₂e). The marginal abatement cost is derived from the MACC analysis undertaken by Escobar et al. (2019) in a number of countries, including in Vietnam.

The MACC is an evidence-based tool available to policy makers to assess the potential for GHG abatement options according to the cost of abatement. It is derived as the ratio of the net present value (NPV) of a GHG abatement option and the amount of GHG emissions abated (in tCO₂e). It is a useful measure of various GHG abatement pathways/options. The MACC is constructed by assessing individual initiatives for their abatement potential and cost and arranging these initiatives in graphical format from the least cost to highest cost order (Ali Almihoub, Mula, and Rahman 2013).

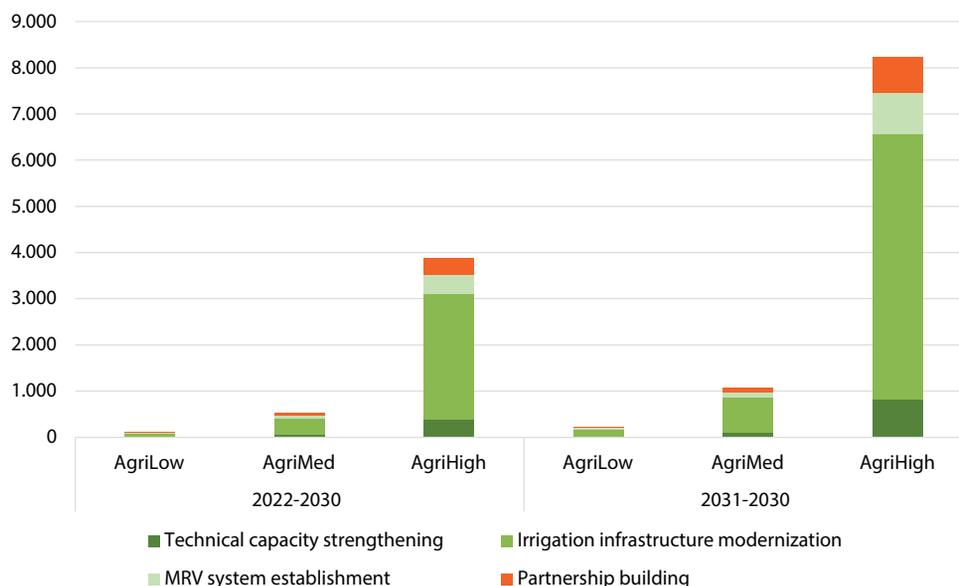
For this report, the key assumptions used in the estimation of the transition costs include the following:

- Vietnam's NDC targets to cut GHG emissions by 6.8 million tCO₂e per year by 2030 (unconditional, using own public resources) and 25.8 million tCO₂e per year by 2030 (conditional target with external support). In the updated NDC, the emission reduction targets were increased to 9 and 27 million tCO₂e per year by 2030 for the unconditional and conditional targets, respectively.
- The estimates assume an average abatement cost of US\$30 per tCO₂e, as recommended by Escobar et al. (2019).
- The period over which the estimates apply is from 2021 to 2040 and aligns with the period over which Vietnam assumes to achieve the NDC targets.

However, some caution needs to be exercised in solely using these numbers to inform policy and decision-making. The magnitude of the estimated cost depends on the assumptions made. Thus, there are likely to be significant variations in the estimated costs if the target GHG emission reduction levels and abatement costs used are different. The analysis serves to highlight that the transition to low-carbon rice will entail significant costs mainly in modernizing irrigation infrastructure, and the longer it takes to do this, the more costly the transition will be.

66. **Despite the considerably high cost, the net benefit is positive in the long run.** This is due to multiple benefits including the value of GHG emissions abated, amount of water saved, and other savings which are difficult to quantify such as reduction in air and water pollution and efficiency gains from production cost reductions. The analysis (earlier sections of this chapter) shows that the use of AWD and 1M5R coupled with appropriate digital technologies increases rice yield, cuts GHG emissions, and serves water as well as fertilizer and other production inputs. The other potential savings would accrue from the repurposing of policy or subsidies or support measures that are deemed environmentally harmful. For example, as is elaborated further in Chapter 4, removing environmentally harmful support measures/subsidies (mostly to rice production) could save about US\$2.49 billion (2019 estimate). Other savings could also come from modernization of rice value-chain infrastructure, including milling facilities to improve storage and milling efficiency, to reduce loss and waste along the rice value chain. Furthermore, promoting sustainable low-carbon rice has the potential to improve food safety (through reduced chemical residues) and reduce water pollution (through reduced leakage of excessive inputs/agrochemicals into water bodies and underground aquifers). It is likely that in value terms, these savings would far outweigh the estimated investment costs.

Figure 14: Estimated transition costs to low-carbon rice (US\$/ha, by target GHG emission reduction scenarios)³⁴



Source: Estimates based on IRRI's modeling and applying unit abatement costs from other sources

67. **To achieve significant reductions in GHG emissions in line with the shift toward low-carbon rice production, the medium- and high-case scenarios would be more appropriate.** The low-case scenario is not an option as it only reduces GHG emission of up to 6.8 million tCO₂e, which is very low relative to the targets established to reach the net-zero emission level by 2040. Vietnam's NDC has two targets for agricultural emission reductions from 2021 to 2030: one without and the other with international financial support. Without support, reductions are targeted at 6.8 million tCO₂e, while with external support they are targeted at 32.6 million tCO₂e.³⁵ Both targets are well below what is judged as feasible with negative net costs of mitigation (that is, 83 million tCO₂e). The funds required for the NDC target assume an average outlay of US\$30 per tCO₂e. The details of what is covered are not provided and the figures have been questioned in a review of Vietnam's NDC (Escobar et al. 2019).
68. The transition is likely to be gradual over this and the next decade. The financing would come from both public and private sources and possibly from the carbon market in the longer run. The transition to low-carbon rice is going to be a long-term process because the investment cost is high and will have to be spread over many years. In the beginning, a lot of the investment cost would have to be borne by the government in modernizing the irrigation infrastructure and putting in place the right policy incentives and institutions. However, over time, the government would have to leverage more private sector spending, in modern value-chain infrastructure and building partnerships with the farmers to support low-carbon rice production. The potential role of carbon market financing, which needs to be explored for low-carbon rice, would also benefit from strong private sector participation. This is critical to incentivize the millions of

34 The costs are estimated based on emission reduction targets set in the country's updated NDC. Vietnam's NDC defines the scenarios as follows: (1) unconditional target of 6.8 million tCO₂e per year by 2030 using domestic resources, (2) conditional target of 32.6 million tCO₂e by 2030 assuming international support, and (3) net-zero level by 2050. For this report, scenario 1 is 'AgriLow', scenario 2 is 'AgriMed', and scenario 3 is 'AgriHigh'.

35 The NDC report has an inconsistency between the amount of reduction in millions of tons of CO₂ equivalent and the percentage such a reduction represents relative to emissions in 2030. It is assumed here that the reduction in tons applies to 2021–2030.

farmers and agribusiness players to participate in sustainable low-carbon practices. The value of the global carbon market hit nearly US\$280 billion in 2020, but agriculture-related emissions' projects account for only 1 percent of all carbon credits issued. In Vietnam, the carbon market is only being implemented in the forestry sector. Vietnam has been implementing three major carbon credit trade agreements on a trial basis. These include the Emission Reductions Payment Agreement (ERPA) signed with the World Bank's Forest Carbon Partnership Facility (FCPF) in October 2020. Under this agreement, Vietnam will reduce 10.3 million tons of carbon dioxide emissions from six North Central provinces until 2025 to receive up to US\$ 51.5 million. There is a need to develop and scale up similar mechanisms to support the low-carbon rice agenda.

SUMMARY

69. **Climate change is a major threat causing more frequent and extreme weather events in Vietnam, such as floods and cold spells in the north and north-central coast, saltwater intrusion in the MKD, and droughts in the Central Highlands** (Nguyen et al. 2017). Therefore, enabling Vietnam's agriculture to transition to a more sustainable, low-carbon path is both necessary and increasingly urgent. This chapter identified two main pathways and a few other related options to cut emissions in the rice sector: (a) improving irrigation and drainage systems, on-farm water management (AWD), and (b) managing inputs (fertilizer and others).
70. **Significant reductions in GHG emissions could be achieved by scaling up the adoption of AWD and 1M5R technologies.** These options are both technically and economically feasible and have been piloted in Vietnam. Promoting these to cover 1.9 million ha under rice production in the Mekong and Red River Deltas over the next decade offers an important pathway to reduce rice GHG emissions.
71. **Promoting other complementary and sustainable practices is also essential.** They include scaling up the use of appropriate digital technologies; shifting from monoculture rice production in unfavorable/unsuitable areas to other commodities such as aquaculture, shrimp, fruits, and vegetables; promoting sustainable post-harvest practices such as reducing the burning of rice residues/husks, improving rice drying and milling infrastructure, and reducing the nonrenewable energy intensity; and more broadly promoting the adoption of climate-smart agriculture (CSA) technologies. Scaling up these options would further reduce emissions while also providing co-benefits including building the resilience and adaptation of farmers to the effects of climate change. Some of these technologies are briefly summarized in Appendix 2. For example, incorporating digital technologies with AWD and 1M5R, such as using digital water sensors (IoT), can reduce water use by up to 30 percent, improve yields by 24 percent, and cut production cost by 22 percent. These can raise net profits while also cutting emissions by 4–6 tCO₂e per ha per year, equivalent to a 60–70 percent GHG emission reduction, assuming 2 rice seasons per year. Such technologies make the transition to a green low-carbon pathway easier and economically more rewarding.
72. **It is possible for Vietnam to shift toward low-carbon rice production, and the medium- and high-case scenarios would bring greater emission reductions, but they would require securing some international as well as private sector support to meet the investment needs.** There is a large pool of international funding that Vietnam could capture for a low-carbon rice transition. To date, public sector engagement has been limited, but there are opportunities to create public-private partnerships. As noted earlier, a carbon tax on GHG emissions offers a strong source of revenue and could be part of a broader carbon market. Accessing the carbon market, however, requires Vietnam to establish an MRV system for agriculture, which does not exist at this time. A recent analysis of potential funding found that there were four potential private donors (all nongovernmental organizations [NGOs]), and about 33 international funding sources, including multilateral development banks, international agencies and institutions, and bilateral sources. Vietnam can access support from some of these organizations (World Bank 2021c).



CHAPTER 4

RECOMMENDATIONS FOR SPEARHEADING VIETNAM'S GREEN AGRICULTURAL TRANSFORMATION BY MOVING TO LOW-CARBON RICE

Key messages

- Vietnam can use its experience to become a leader in low-carbon rice/agriculture through systematic progress on the following goals: cutting GHG emissions, increasing resource use efficiency and yields, improving resilience, and diversifying production.
- The key to achieving these goals at scale is to align incentives and coordinate behaviors of various stakeholders at different levels, from the farm up to the national economy.
- It is important to ensure that the strategy and action plan for low-carbon rice are nested within a broader strategy of transition to a green, resilient, and inclusive agri-food system.
- The government can propel the LCT in five distinct ways: improving policy coherence and plan-budget alignment; repurposing policy tools and public expenditures to support LCT; promoting investment in low-carbon rice/agriculture; strengthening institutions; and enabling the private sector and other stakeholders to adopt low-carbon practices.
- The government's new agricultural strategy provides an invaluable opportunity to scale up the LCT through the development of suitable implementation action plans.

INTRODUCTION

73. **This chapter builds on the review and analysis of prior chapters and international experiences and best practices to discuss key elements of the strategy and action plan to promote low-carbon rice in Vietnam.** However, given the centrality of rice to agricultural climate change issues in Vietnam as well as its outsize significance in agricultural public policy, in terms of public expenditures and supportive interventions, it is essential to ensure that the strategy to move to low-carbon rice is nested within a broader strategy for green transformation of agriculture in Vietnam. This particularly requires attention to issues of resource use efficiency, diversification, focus on agricultural livelihoods, and enhancement of resilience. To successfully pursue a low-carbon rice strategy, consistent with the green agricultural transformation vision and objectives of the government, a five-point agenda for actions is suggested, along with next steps for planning and implementation.

PROMOTING LOW-CARBON RICE

74. **Building on its experience, Vietnam can become a leader in low-carbon rice production.** As mentioned in Chapter 3, Vietnam has already gained strong experience and positive results in this regard, through the IDA-supported VNSAT and ACP operations, which implemented the AWD water management technique and the '1M5R' rice management practice. Taken together, these low-carbon cultivation approaches have been adopted by nearly a quarter million farmers and across over 200,000 ha. They have resulted in significant reductions in GHG emissions and intensity of input use along with significant increases in productivity and profitability. The Vietnam experience has also been regarded as an instructive example internationally.
75. Vietnam can achieve low-carbon transformation of the rice sector through systematic progress on the following goals:
- **Cutting GHG emissions**, directly, through improved irrigation, with better infrastructure and on-farm water management, improved fertilizer management, improved straw/residue management, and reduced stubble and husk burning and indirectly, through reducing energy intensity by improving the efficiency of pump irrigation and promoting the use of 'green' renewable energy, including through solar power for irrigation, milling, and processing.

- **Increasing resource use efficiency and yields.** The above reduction in GHG emissions could be further increased by using improved rice varieties and making more optimal use of other inputs, increasing milling efficiency, reducing food loss and waste, and using digital approaches to enhance efficiency of the rice value chain.
- **Improving resilience** by promoting risk management capacities, targeted support systems, and relevant assets and/or robust coping strategies that enhance the resilience of rice farmers, communities, and ecosystems, especially to weather volatility (climate change) and market volatility.
- **Diversifying production** away from rice—which can trap smallholders in low-returns agriculture livelihoods—into aquaculture, fruits and vegetables, and other crops with lower GHG footprint, to produce both climate- and income-related benefits.

76. **The key to achieving these goals at scale is to align incentives and coordinate behaviors of various stakeholders at different levels, from the farm up to the national economy.** Illustratively, these actions would include the following:

- **Farm level:** Investments in land preparation; improved on-farm water infrastructure and irrigation practices; increased mechanization of sowing, transplanting, and harvesting to reduce input use and harvest loss; use of climate-resilient high-quality seed varieties and modern inputs; improved farming techniques for nutrient, disease, and overall crop management; and switch to greater use of renewable energy sources.
- **Scheme/system level:** Providing reliable water storage through dam safety and modernization; upgrading/modernizing irrigation systems for more flexible and demand-focused services (for example, cell phone-controlled irrigation systems); improving drainage systems for better farm-level drainage and to cope with seawater intrusion and flood issues in the MKD; enhancing information services through sensors, embedded processing systems, user software, and other technologies to provide specific and locally customized support (for example, through 'IoT').
- **Regional/national level:** Market development and trade promotion; enhancement of access to markets, especially among the most vulnerable and the poorest farmers (for example, ethnic minorities, women); support for development of storage and logistics systems; value chain development, through leveraging private sector engagement; development of credit scheme for value chain financing and development.
- **Cross-cutting:** Focusing on institutional reforms and capacity building; supporting participatory irrigation management including by strengthening water user associations; reforming irrigation agencies for demand-responsive service delivery; strengthening farmer collective groups/cooperatives and producer alliances to benefit from economies of scale; improving coordination across systems; and focusing on inclusion to strengthen last-mile service delivery and outreach to the poorest farmers.

TOWARD A STRATEGY AND ACTION PLAN

77. **It is important to ensure that the strategy and action plan for low-carbon rice are nested within a broader strategy of transition to a green, resilient, and inclusive agri-food system.** This is for several reasons. First, rice dominates public policy making in agriculture in Vietnam. Despite its small and dwindling contribution to agricultural GDP, rice accounts for the lion's share of public spending in agriculture. This crowds out public expenditure for other, higher-value crops like horticulture and livestock, creating a non-level playing field between rice and the other crops (which suffer from lack of the much-needed public support to power their growth). Second, in common with other rice-dominant economies of East Asia, highly distortionary policy instruments—subsidies, price supports, and trade restrictions—have been used

to support rice production. This has, on the one hand, led to overuse of fertilizer, water, and other resources (causing pollution and other negative effects) and, on the other, has 'trapped' a large proportion of small farmers in low-returns rice production. Third, as noted in earlier chapters, rice production is also closely related to climate change, both contributing to and impacted by it.

78. **Hence, while seeking to shift to low-carbon rice, it will be helpful to link with the broader green agricultural agenda, to enhance vibrancy and sustainability of the entire agri-food system.** This will require rebalancing of current rice-centric agricultural policy and public expenditure system. For instance, public spending in agriculture may need to be repurposed away from current forms of support to rice into investments that enhance productivity, innovation, variety, quality, and agricultural income growth. Similarly, reforms may need to focus on, as well as beyond, rice to diversify food sources, boost productivity, expand processing, deepen trade, promote competition, and enhance sustainability.

Five dimensions of public action

79. **Experience suggests that the government has a catalytic role to play in aligning objectives, strengthening incentives, and creating an enabling environment for various stakeholders to make timely and well-informed decisions for transition to sustainable low-carbon rice and, more generally, low-carbon agriculture.** The government can contribute in five distinct ways:
- Ensuring policy coherence and plan-budget alignment
 - Repurposing policy tools and public expenditure to support LCT
 - Promoting investment in low-carbon rice/agriculture
 - Strengthening institutions
 - Enabling the private sector and other stakeholders.

A. Ensuring policy coherence and plan-budget alignment

80. **The success of LCT depends upon coordinated and convergent actions by millions of stakeholders.** From farmers and input providers to processors, traders, and consumers, individual decision-makers need to change their decisions and behaviors based on their awareness and understanding of carbon costs, longer-term risks, and technological and business opportunities. It is crucial for the success and sustainability of the LCT that public policies and interventions do not send out confusing signals or create conflicting incentives and/or distortions, to the extent possible. Given that the transition to low-carbon rice/agriculture already stands at the intersection of three big agendas (climate change, agricultural development, and food security), each with its own set of objectives, drivers, policies, programs, and institutional arrangements, it becomes even more important to ensure vision, policy, and program coherence.
81. **Experience suggests that the government can help in three critical ways in this regard:** (a) aligning international and national goals and commitments with sectoral objectives and policies; (b) ensuring plan-budget alignment, so that public expenditure can more effectively be deployed to implement plan priorities; and (c) systematic and inclusive assessment of current policies and programs for their intended and unintended effects on the set of development objectives prioritized by a country—in the case of transition to low-carbon agriculture, the three objectives are reduction and removal of GHG emissions, sustainable increases in agricultural productivity and incomes, and climate change adaptation in the agriculture sector.

82. **Vietnam is well advanced in terms of formulating national objectives and policy frameworks that are well aligned with international agreements, commitments, and trends.** Vietnam has made international commitments both to reduce global GHG emissions and to adopt green growth strategies across multiple sectors, including agriculture. As mentioned earlier, the agriculture sector is expected to play a critical role in meeting Vietnam's NDC, including commitments to the UNFCCC to cut methane emissions by 30 percent by 2030 and achieve net-zero levels by 2050 as part of its COP26 commitments. Further, the government has formulated a new Strategy for Sustainable Agriculture and Rural Development for 2021–2030 with a Vision to 2050, approved through the Prime Minister's Decision No. 150/QD-TTg of January 28, 2022, which prioritizes resilient, green, low-carbon agricultural transformation.
83. **To ensure implementation of national objectives, coordination in CSA planning and budgeting among different agencies at the national, provincial, and local levels is critical.** Toward this end, budgetary financing needs to be closely aligned with the policy objectives as well as associated with agencies responsible for implementing actions. Action plans need to be developed that set out medium-term goals and priorities for specific sectors and contain time-bound implementation targets and plans. Finally, implementation of sectoral plans needs to be supported by customized monitoring mechanisms.
84. **Finally, there is a need to enhance synergies and remove disconnect between existing policies relating to climate change, agricultural development, and food security, which all affect low-carbon development goals.** These policies are typically formulated and implemented by different ministries and agencies, creating sectoral silos, which can generate confusing, if not conflicting, signals at the level of farmers and other stakeholders and decision-makers. Lack of coherence can produce distortions and block change despite fiscal and other support provided through specific schemes.

B. Repurposing policy tools and public expenditures

85. **To robustly scale up low-carbon rice, and low-carbon agriculture, more generally, it is essential to analyze and adjust existing policies, public expenditures, and other support measures as well as fill in any policy gaps with relevant fiscal or regulatory instruments.** This section provides an assessment as well as recommendations with respect to a wide range of policy tools and instruments currently in use in Vietnam as well as some that could be potentially brought into play.

B.1. Market-based Instruments

Taxes and subsidies on inputs and outputs

86. **As in other dominant rice economies, Vietnam over the decades supported rice production by providing various forms of stimulus for agricultural (for example, input or output subsidies as well as market support) to farmers.** However, subsidies and support measures for fertilizers, energy, and water have distorted farmer incentives for efficient use. For example, irrigation fee exemptions or the price subsidy for irrigation services discourages farmers from saving water. Further, lack of financial resources for operations and maintenance—worsened by non-recovery of irrigation service fees—results in irrigation works not being adequately managed, repaired, or upgraded. Similarly, credit, import tariff, and tax measures aimed at helping agricultural input suppliers and farmers have the effect of reducing the relative cost of fertilizers and pesticides, thereby encouraging farmers to over-apply these inputs. This has contributed to high average agricultural input application rates among farmers in Vietnam, resulting in high carbon, methane, and

nitrous oxide emissions.³⁶ It should be further noted that agricultural support measures provided to farmers and agricultural actors are largely classified as mostly environmentally harmful.

87. **In this regard, the report recommends that the government should promote more effective use of natural resources in Vietnam by adjusting prices for inputs that more closely reflect their scarcity value and by better targeting of taxes, subsidies, property rights, and other payments.** Specifically, this can be done by:
- Reviewing options for charging irrigation fees to improve water productivity and incentivize efficient water use, including expanding pay-for-service principle (cost recovery in irrigation) to reduce overuse of water and promote operations and maintenance; and
 - Revising any support on fertilizers to reduce distortions and perverse incentives, complemented by good agriculture extension support, thereby limiting fertilizer overuse and promoting healthier plant nutrient management by farmers.

Market creation support

88. **Currently, the market for climate-smart rice and the supply chains for sustainably produced rice in Vietnam are limited and underdeveloped.** At present, there are limited market mechanisms in Vietnam for rewarding farmers for producing climate-smart rice. Yet, consumers in developed countries are increasingly showing preferences for products that meet climate, workers safety, environmental, and other health standards. Vietnam's lack of ability or standards for tracking and verifying these 'premium' products further reduces farmers' incentive to switch to greener, lower-carbon, and more profitable rice production. Moving forward, it will be important to enable 'market creation' through measures to support well-functioning input and output markets as well as accreditation and certification systems that are key to the emergence of markets for sustainable products.

Trade-based instruments

89. **The government can take actions to rationalize trade regimes to align better with green goals.** Potential actions include the following:
- Review tariff and non-tariff barriers and export subsidies on food and agriculture products to examine their potential impact on sustainable resource use and environmental concerns, such as biodiversity; and
 - Proactively support value chains to meet the demands for greener products, along with the associated conditionalities (including standards and certification) being driven by consumers in international markets.

³⁶ Circular 41/2013/TT-BTC free irrigation (expired 3/8/2020) and Decree 96/2018/ND-CP of the Government: Detailed regulations on prices of irrigation products and services benefits and support for the use of irrigation products and services. The government also put in place Decree 54/2015/ND-CP on preferential credit, tax exemption, and reduction for actions using and saving water effectively such as recycling water, circulating water, collecting rainwater for internal use, collecting rainwater for reuse, treating saltwater into fresh water, producing and importing water-saving technology and equipment, and applying technical technologies to save water in agricultural production. Without implementing an economic fee for water use (in irrigation), there is no incentive to use it efficiently.

B.2. Regulatory instruments

Land tenure and land use planning

90. **The structure of land ownership and management in Vietnam, especially in the rice sector, has led to multiple problems**, including restrictions on rice land use and ownership, requiring land to be used for rice production only, high levels of land fragmentation, and the private sector's reluctance/inability to engage in production. Inadequate land valuation discourages private investment, including those required to transition to a low-carbon agriculture. Together, these result in suboptimal land use efficiency and weaken Vietnam's agricultural sector. For example, over 42 percent of farm households have less than 0.2 ha (2020) with only about 3 percent having over 3 ha (see Appendix 1). At such small and fragmented scales, it is hard to realize efficiencies. Box 3 shows the earlier recommendations made toward the Review of the 2013 Land Law – particularly those aimed at promoting flexible land use in agriculture.

Box 3: Recommendations for the review of the 2013 Land Law in Vietnam

Vietnam's rapid and sustained economic growth and poverty reduction in the last two decades have benefited from intensive use of natural resources, including the land through the policy and legal reforms embodied in the Land Laws of 1987, 1993, and 2003 and subsequent related legal acts. However, land reforms in Vietnam have not had similar success in improving flexibility of agricultural land use compared to other countries such as China. The average farmland size in China (excluding cooperatives and companies) is quite similar to that of Vietnam (that is, 0.6 ha per farm household in 2013). However, as of 2016, nearly 40 percent of farmland in China contracted to farmers had been transferred to agricultural enterprises and professional cooperatives, compared to about 1 percent in Vietnam, mainly due to China's facilitation of the land rental market (Liu 2018). Going forward and to align with sustainable and resource-efficient agriculture, there is a need to promote a more flexible land use in agriculture, which allows farmers to shift land use in accordance with comparative advantage. The World Bank has since 2012 outlined land law recommendations to aid this flexibility in three main themes.

First, land tenure in agriculture is limited to 20 years for annual crops, aquaculture, and salt production and 50 years for perennial crops and forests for households and individuals (Art. 67). Establishing a longer or unlimited term of agricultural land use by households and individuals will help farmers adopt more effective and environmentally sustainable land use practices and greater incentive to invest on the land.

Second, land allocation is limited to 3 ha for annual agricultural land; 10 ha for perennial crops in the plain areas; and 30 ha for perennial crops in highland, mountainous areas, and forest land (Art. 70). The limit for landholding by land transfer is defined by the National Assembly's Standing Committee (currently, it is twice the land allocation limit). There is a need to ease the existing agricultural landholding limits for households and individuals to incentivize higher investment and productivity and economies of scale and agricultural transformation. Raising landholding ceilings allows for greater land accumulation.

Third, permission is required from the relevant state body to convert rice land to perennial crop, forest, and aquaculture land (Art. 36). The state "preserves land specialized for wet-land rice farming" (Art. 74). Easing the current limitations on alternative uses for so-called 'designated rice lands', at least for those where mono-crop rice cultivation is not economically viable is important to enable higher efficiency, increased rice-growing farmers' incomes, and reduced threats of land degradation due to diversification. This scope for more flexible land use will become increasingly important in the context of climate change and the need to promote low-carbon agriculture by allowing farmers the ease to make a range of adjustments based upon expected weather patterns and the associated risks. Developing a more flexible and effective land planning management system and improving transparency of land use management are needed to take Vietnam's land governance system closer to that worthy of a middle-income country.

Source: World Bank 2012.

91. **It is essential to reduce and remove the legal, regulatory, and administrative barriers to a more flexible land use**, especially for the large areas of designated paddy land, and foster a more active land (use) market. Conditions that facilitate investments in land and how land is allocated to higher-value uses can raise land productivity and lower GHG emissions while supporting sustainability. Actions to consider include the following:
- Fostering and facilitating land consolidation by strengthening the legal frameworks for transferring agricultural land use rights (such as transfer and lease) by (a) increasing the current ceiling on landholding sizes and (b) setting up a market for transferring LURs with transparent rules and low transaction/administrative costs (for example, the Provincial People's Committees could set up these markets [Service Centers for Land Renting] to support land renting between agri-business investors and current agriculture land users to enable larger-scale agriculture);
 - Improving land valuation by (a) establishing a land valuation authority and (b) requiring that certified appraisers/valuers undertake valuations for all purposes. Additional recommendations are provided by the World Bank review of the Land Law of 2013 (World Bank 2012);
 - Promoting flexibility in land use, by reviewing regulation (Decree 01/2017/ND-CP) that prevents farmers from converting paddy land to livestock and aquaculture;
 - Adjusting land policies for land rental and providing guidance on land policies for organizations and individuals to rent land for other activities such as livestock development, industrial slaughtering, preservation and processing establishments, and environmental pollution control; and
 - Revisiting regulations that exclude nonagricultural households and enterprises from receiving paddy land to stimulate the flow of new capital and entrepreneurship into agriculture.
92. **In the longer term, it is important to allow flexible land use to shift away from mono-rice systems to rice-based integrated cropping systems to improve farm incomes and agricultural livelihoods and develop a high-end market for low-carbon rice (with new branding for Vietnamese rice).**

Strengthening environment regulations

93. **Vietnam has many existing laws for environmental standards, but there is weak enforcement.** It is a signatory to many international agreements for biodiversity, climate, land degradation, and the SDGs. Additionally, there are many national policies regulating what can broadly be characterized as environmental health and safety. But implementation and enforcement remain weak or undermined by conflicting policies and other government actions (for example, subsidies).
94. **There is a need to strengthen and rationalize the legal, regulatory, and enforcement systems to raise environment standards;** obtain improved environmental outcomes; more effectively manage pollutants and agrochemicals; conserve and manage natural resources and ecosystem services; and broaden environmental regulations. Specifically, the critical actions include
- Enacting and enforcing controls on reducing excessive use of agrochemicals and fertilizers;³⁷
 - Implementing and strengthening agreements for biodiversity, forests, water, and soil quality; and
 - Improving enforcement of environmental regulations and standards and certification from the farm gate to the retail sector.

37 To maintain the competitive position of the agricultural export sector, it is essential to ensure that these regulations and targets are aligned with developments in key export markets. For instance, even though there is no proposal at this stage for a carbon border tax on agricultural products in the EU, de facto standards may be raised by changing consumer preferences as well as the introduction of 'mirror clauses' by the EU which can raise production, safety, and health standards of imported products.

B.3. Refocus and Repurpose public expenditures

Distortional patterns and impacts

95. **The bulk of agricultural support in Vietnam continues to be provided in the form of distortional subsidies and or price/market support, rather than 'direct', decoupled payments to farmers.** While the share of distortional subsidies has been declining, from 97 percent in 2010 to 77 percent in 2019, there is clearly a need to do more.
96. **A large proportion of the subsidies provided by the government are also deemed 'environmentally harmful'.** Some potentially less environmentally harmful support measures (direct payments based on current or non-current areas/animals, decoupled direct payments with no production required) were gradually introduced starting in 2010 and grew by 2019 to represent nearly 23 percent of total support provided. This share needs to be significantly increased to more strongly promote environmental goals. Like most Organisation of Economic Co-operation and Development (OECD) countries, Vietnam could also make agricultural support conditional on environmental objectives.
97. **Current public funding does not include adequate provision for operations and maintenance or R&D and other areas required to promote climate resilience and adaptation.** For instance, spending on science and technology is marginal, estimated at about 0.4 percent of total spending in the sector, compared to the average in the East Asia and Pacific region, estimated at 1–2 percent of GDP. Private spending for climate adaptation and mitigation in agriculture is also only about 1 percent of total sector spending.
98. **More generally, there is a need to restructure public expenditure to favorably influence the options available to, and the technical choices made by, the millions of farmers in Vietnam.** Specific recommendations in this regard include the following:
- Progressively de-link farm support from commodity production levels and prices. Urgently review the policy framework to assess the feasibility of phasing out the most distorting and environmentally and socially harmful forms of direct (producer) support.
 - Redirect subsidies into providing training and goods and services enabling farmers to adopt more productive and profitable production practices that also produce adaptation/mitigation benefits. There are many production practices that increase both profitability and climate benefits, including resilience to climate change, as discussed in this report.
 - Develop and pilot a scheme for payment of environmental services that remunerate flows of environmental public goods (for example, biodiversity, carbon sequestration, and flood and drought control) beyond designated reference levels and targeted to environmental outcomes.
 - Use repurposed public support to target environmental outcomes where feasible; otherwise target production practices favorable to more sustainable practices (for example, AWD and 1M5R).
 - Target public investments toward green technologies.
 - Increase the share of public expenditures in agriculture on 'general services in support of agricultural development'.

Underspending on technology and innovation

99. **Increasing public spending for science and technology is critical to drive knowledge, innovation, and adoption of sustainable production practices that are indispensable for low-carbon agriculture**

transformation. However, in Vietnam, spending on R&D, science, and technology is marginal, estimated at about 0.4 percent of total spending in the sector, compared to the average in the region estimated at 1–2 percent of the agricultural GDP. For example, the return on investment in irrigation (for rice) is lower than that from R&D, yet expenditures to support knowledge and innovation, market promotion, inspection, and control services are minimal (see Appendix 1). R&D investments can have a huge payoff. For example, using the IoT under the AWD system of irrigation increases water use efficiency by up to 30 percent above the current level achieved. Similarly, investments in e-extension, e-commerce for inputs/crop marketing, and information and decision support systems can improve value chain efficiency and adoption of sustainable low-cost, low-carbon technologies significantly (see Appendix 2).

100. International experience and good practice examples illustrate that Vietnam should undertake the following actions:
- Boost public expenditures on research, development, and dissemination of new, low-carbon technologies (such as climate-resilient low-emission seed varieties, water-saving technologies, improved post-harvest technologies, and other value chain infrastructure).
 - Invest in data systems and digital technologies (for example, public use datasets on agriculture production, digital farmer registry, digital payment infrastructure, and e-extension) to accelerate the transition to low-carbon agriculture.
 - Create partnerships and platforms, involving key stakeholders in the rice value chain (MARD, Departments of Agriculture and Rural Development [DARDS], cooperatives, businesses, and so on), for promoting sustainable production focused on, for example, public-private partnerships in infrastructure investments, research and innovation, and marketing opportunities; increasing research; and expanding extension services on sustainable food and agricultural systems.
 - Assess the feasibility of promoting private green agricultural R&D through grants and tax credits with relevant public and private partners.

C. Promoting investment in low-carbon rice/agriculture

101. **The shift to low-carbon agriculture will require significant investments.** At the farm level, these could be in, for example, land preparation, on-farm water management, new seeds, technologies and inputs, and so on. Beyond the farm, too, investments in new technologies, management systems, and digital approaches will be needed to ensure more efficient, 'green' use of inputs and resources. Also, the infrastructure and equipment along the rice value chain are outmoded and need to be modernized to improve efficiency along the value chain. However, current conditions in rice production and agriculture more generally are not favorable for investment by farmers or the private sector.
102. **Shifting to more sustainable and lower-emissions production can entail high up-front costs and risks, which most Vietnamese farmers may not be able to afford.** Typically, rice farmers have small, fragmented holdings and modest incomes and lack collateral and information on their creditworthiness. According to the 2018 VHLSS data, the average farm household net income per hectare per year for rice was estimated at VND 8.763 million (US\$377) while it was VND 11.688 million (US\$502) for perennial crops, VND 29.273 million (US\$1,259) for livestock, and VND 20.860 million (US\$897) for fisheries and aquaculture. With such low profit margins, it is implausible for farmers to adopt sustainable production practices that have high upfront costs or risks, since they are very likely to attach higher value to current livelihoods needs.

103. **The government can catalyze investments in low-carbon agriculture across Vietnam** through (a) enhancing investment capacity at the farmer level, (b) ‘de-risking’ investments by the private sector, and (c) promoting access to carbon finance. Mobilization of private sector capital for low-carbon agriculture is critically important. Analysis of public expenditure aligned with climate mitigation and adaptation in agriculture suggests that public spending is likely to be able to meet only 30 percent of the overall resource requirements to meet the climate targets for 2030.
104. **To enhance investment capacity at the farmer level, the government can undertake the following actions:**
- Promote financial literacy and mobilize extension services to work in partnership with microfinance institutions (MFIs), banks, mobile money providers, and other fintech players, to enhance farmers’ financial literacy, especially on (a) payment and credit schemes, (b) use and potential impacts of mobile platforms; and (c) their legal rights and contractual obligations for digital payment agreement.
 - Promote various forms of collateral other than land (such as structures, equipment, commodity inventories, and receivables) as the basis for agriculture lending through (a) legislation identifying the roles and responsibilities of the different parties involved; (b) legislation that facilitates using construction and structures on land as collateral; (c) establishment of an authority that oversees warehouses; and (d) development of a public registration system for warehouse receipts that builds trust in the system, enhances its transparency, and mitigates fraud risks.
 - Facilitate digital financing in agriculture by enabling growth of digital platforms and new methods of calculating digital credit scores, especially for mostly ‘un-bankable’ smallholder farmers (for example, using data such as that generated by mobile money transactions, per the lessons and experiences from other countries, including China, Indonesia, Mongolia, and Kenya).
105. Similarly, the government can stimulate investments in low-carbon agriculture and building of climate resilience by improving agricultural insurance markets to ‘de-risk’ agriculture investments through:
- Investing in public goods supporting the design of high-quality insurance products (such as open and reliable datasets on yields, losses, and R&D) for smallholder farmers (for example, index insurance products, and digital mobile-based insurance); and
 - Acting to reduce insurance premiums sustainably by the following:
 - Risk layering, that is, promoting approaches to spreading the risk across the public and private sectors (for example, premiums for catastrophic risks covered by public subsidies and premiums for recurrent risks paid by farmers and other agriculture investors).
 - Bundling insurance with credit. Studies show that farmers who are insured obtain cheaper credit, so the public sector could fund bundled insurance and credit products.
 - Bundling insurance with credit, improved seeds, and inputs has dual advantages of de-risking the investment in improved inputs and encouraging insurance product use.
 - Repurposing insurance subsidies to support low-carbon crops and practices by linking any subsidy to adopting low-carbon crops and practices and expanding insurance-eligible crops (beyond rice, livestock, and aquaculture) to include low-carbon intensity crops.
 - Building the capacity of stakeholders, including staff of National Statistical Agencies, Ministry of Agriculture, and other relevant agencies.

106. Finally, the government can also promote access to climate finance through the following:
- 'Blended' (public and private) finance to de-risk investments, where the public sector provides a first-loss absorbing capital cushion to attract private investors.
 - National guidelines for tapping into available blended finance facilities put in place by multilateral development banks.
 - Development of an institutional framework that helps farmers access additional resources through the emerging carbon market.
 - Establishment of a robust MRV system. A robust MRV system for GHG emission and climate co-benefits that ensures accountability, transparency, and good governance will help build the confidence of international and private sector providers of climate finance. It would also generate data and foster information sharing with the private sector, NGOs, public sector, and international actors.
 - Support for the use of on-farm digital, real-time technologies to measure, report, and receive payments for GHG emission reductions. Farmers transitioning toward sustainable production practices and achieve verifiable emission reduction can be certified to earn carbon funds as an incentive for them to enhance and sustain such practices.
107. **In the longer term, significant benefits may be obtained from enabling farmers to access carbon credit.** They could be used to create incentives for them to adopt improved farming practices. Toward this end, the government needs to catalyze these developments by working with farmer groups and civil society to improve the awareness of farmers about these opportunities and provide relevant training and to facilitate monitoring systems and infrastructure upgrades to enable farmers to verifiably access carbon credits.

D. Institutional strengthening

Role evolution

108. **The government needs to transition from direct involvement in the sector to a more facilitating role.** Experiences from other countries undergoing agricultural transformation show that state-led development has to give way to more flexible systems to help the agri-food sector nimbly respond to new challenges arising from international markets, geopolitical situations, and climate change. Toward this end, it is critical to establish well-defined property rights (including clear and enforceable contracts), promote inclusive planning, and strengthen administrative capacity of provincial offices and local tiers. Although state control and management in both input and output markets has declined over time, more needs to be done in this regard. The share of agribusiness in agricultural sector GDP is among the lowest in Vietnam.

Upgrade institutional capacities of MARD

109. **Sectoral institutional capacities need to be upgraded to match and support the vision and policy goals of a modern, diversified, sustainable, and high value-added agricultural sector.** Institutional challenges particularly relate to capacities to (a) enforce environmental regulations and promote sustainable production, (b) generate and disseminate information transparently, (c) effectively coordinate between the center and the provincial entities, and (d) drive innovation and increase efficiency. Specific recommendations include the following:
- Strengthening the extension capacities (public and private) for green agriculture and ensuring that capacity needs in the form of training and information are met. Investment in capacity building was

identified as the single largest barrier to CSA adoption across all regions, affecting almost 90 percent of all interventions. Such capacity building is needed for farmers, experts, and decision-makers alike, with knowledge dissemination through public extension services, universities and academia, and the private sector. This is vital to adopt CSA to ensure that new and potentially complex, integrated measures are implemented.

- Incorporating sustainable approaches in training, education, and advice programs throughout the food chain.
- Strengthening MARD's and DARD's capacity to monitor the environmental impacts of policies and investments by (a) establishing Environment Divisions within MARD and DARD (currently, only the Department of Livestock Production has an Environment Division), (b) training MARD and DARD staff on the using advanced digital technologies to monitor environmental impact, and (c) developing capacity in MARD to implement an MRV system for agriculture.
- Promoting public incentives to foster private sector investment in the use of digital and remote sensing tools, technologies, and data systems for more accurate and timely monitoring and assessment of environment and natural resources.
- Strengthening institutional coordination and collaboration between MARD and other relevant ministries and entities implementing agricultural programs.
- Strengthening farmer cooperatives' capacity through training programs (technical, managerial, accounting, legal, and regulatory), accreditation schemes, and so on and by providing tax and other financial incentives to businesses to work with cooperatives.

E. Enabling the private sector and other stakeholders

110. **Private sector investment in agriculture is limited in Vietnam, especially compared to other sectors.** The private sector in agriculture, fisheries, and forestry sectors accounts for only 1.3 percent of total registered businesses in Vietnam, and over 95 percent are small and medium enterprises, and half are microenterprises (with less than 10 employees). Enterprises cite problems with the relatively high cost of starting and running a business, in terms of bureaucratic red tape, unfair competition with state-owned enterprises (SOEs), limitations and administrative procedures required to access land, and the reluctance of banks to lend to agro-based businesses. The 2020 Country Private Sector Diagnostic (CPSD) by the International Finance Corporation (IFC) highlights these challenges, although they likely vary depending on specific subsectors within agriculture. Total foreign direct investment (FDI) in Vietnam's agriculture sector accounted for only about 1 percent of the total FDI into Vietnam (compared to a global average of 3 percent) for 2010–2019. Policy changes are essential, and so is improving green value chains. Embracing technologies and competencies, such as digital literacy, among farmers and other players along the agricultural value chain can help expand the role of the private sector in agriculture.
111. **The transition to low-carbon rice and green agricultural transformation would benefit greatly from stronger partnership with the private sector.** There is a strong need to create an enabling environment and facilitating conditions for greater private sector entry. Some of these have been addressed earlier (for example, finance and insurance), but a key component is supporting smallholder inclusion in value chains, through the following:
- **Supporting farm clusters and 'horizontal' integration.** These can enhance coordination and resource sharing among farmers because rice growing is particularly well suited for collective action: farmers use a common water source for irrigation; their demands for labor peak simultaneously (tilling, planting,

harvesting), requiring a good level of coordination to avoid labor shortages; and machinery and equipment tend to be both uneconomic and unaffordable for individual farmers, justifying their joint ownership/lease models. In this regard, the public sector can promote enabling conditions (for example, investments in complementary/local infrastructure) and/or strengthen incentives for development of agro-based clusters (subsidizing land, machinery, and business development services). Several countries in Southeast Asia have had successful experiences with these approaches (See Appendix 2).

- **Promoting farmer links with sustainable productive alliances.** The absence of a viable business model for low-carbon products (for example, rice) limits the financial infrastructure to service millions of smallholders who lack access to services. Moreover, the limited public financing for governments to attract private sector investment through blended finance instruments and the lack of credibility to leverage international climate finance to attract private sector investment for climate-smart agricultural production are also key factors that would greatly affect the scaling up of low-carbon production practices. However, models such as the Sustainable Rice Platform (SRP) standard present an opportunity for scaling up low-carbon rice production techniques (Box 4 and for more details on SRP see Appendix 2 provides).

Box 4: Sustainable Rice Platform

The SRP Standard for Sustainable Rice Cultivation is the world's first voluntary sustainability standard for rice. The SRP is a global multistakeholder alliance launched in 2011 and led by UN Environment, IRRI, and German Agency for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit, GIZ), comprising over 90 institutional stakeholders, including public and private sector stakeholders, research and financial institutions, and NGOs. The SRP's goal is to minimize the environmental impacts of rice production and consumption while enhancing smallholder incomes and contributing to food security.

The SRP standard presents an opportunity for scaling up low-carbon rice production techniques. It provides a mechanism to improve the flow of finance to sustainable practices in the rice value chain based on public-private collaboration. The SRP provides a mechanism through which up-front investment needed for companies, suppliers, and farmers to switch to climate-smart production methods can be made. Through the SRP, sustainable sourcing contracts for climate-smart rice are forged between the key players in the rice value chain. Better coordination is fostered between millers and processors who act as a key point of aggregation for farm produce and warehouse receipt operators who enable farmers to deliver their produce to a warehouse where they are presented with a receipt that can be used as collateral for obtaining credit from banks or MFIs. This in turn provides farmers with a viable form of collateral and mitigates the risks involved in lending to them and allows them to access loans at lower interest rates. Through the SRP, contracting mechanisms to buy sustainable rice from farmer cooperatives to ensure quality and traceability and developing brand value from sustainable rice linked to a lower environmental footprint and fairer trade to position sustainable rice in local, regional, and global markets are made possible through appropriate offtake agreements. A series of contractual arrangements along the value chain can help lower risks and increase access to capital. For example, offtake agreements—by which a company makes a promise to buy a certain volume of a crop at a fixed price at a certain date in the future—are a useful risk mitigation tool in smallholder farming. This can create three-way relationships between farmers, processors, and banks where banks provide credit to farmers, farmers sell their produce on a forward contract to processors, and processors then repay the loan to the banks.

In Vietnam, only 8 percent of the rice farmers have been able to meet the SRP standards. Some of the large-scale rice supply chains such as global agri-business Olam International, which is also a member of the Better Rice Initiative Asia, is working with almost 3,000 farmers and intends to reach 10,000 smallholder rice farmers by 2022 in Vietnam's MKD region, to increase production in a sustainable way and secure long-term supply. There are also many other companies working in the rice value chain that have expressed plans to transition toward low-carbon rice.

Source: Sustainable Rice Platform 2019.

112. **Rethinking the relative roles of the public and private sectors.** There are great opportunities for productive partnerships with the big private sector companies to offer market-based solutions to promote low-carbon rice and broader agricultural transformation. For example, major multinational, regional, and domestic agricultural companies can play a greater role in providing financing solutions and cutting-edge R&D including in digital and high-tech solutions. There is thus a need to rethink the relative roles of the public and private sectors to spearhead green, low-carbon agricultural transformation in Vietnam. Specific recommendations on this are highlighted below:
- Leveraging digital technologies and platforms. Digital technologies for traceability, such as sensors, e-platforms, and blockchain can facilitate end-to-end traceability of the supply chain, increasing consumer trust, and allow niche markets with favorable price premiums to develop. Supporting development of digital platforms which can help match producers with service providers and final customers can reduce the number of intermediaries and transaction costs. This can contribute to expanded business volume, competitive prices for consumers, and higher price share for producers.
 - Establishing technology funds and associated protocols to support green entrepreneurs, especially among the younger (millennial) and more tech-savvy farmers.
 - Reducing the digital divide by working with the private sector and other stakeholders between rural and urban areas to (a) promote e-literacy among smallholder farmers, by scaling up e-extension services among smallholder farmers; (b) engage the Vietnam Digital Agriculture Association (VIDA) to grow tech-hubs or smart AgriHubs (digital innovation hubs) and start-ups (for example, by youth entrepreneurs) to develop digital solutions and relevant digital content tailored to the needs of various stakeholders along agricultural value chains (especially small-scale farmers and enterprises); and (c) boost rural digital infrastructure (that is, mobile services and internet broadband); strengthen protocols for data privacy, security, and interoperability; and address, in real time, potential liability issues associated with digital technology.

CONCLUSION AND NEXT STEPS

113. **Vietnam's agriculture will need to undergo a paradigm shift, involving several changes in direction and deep-seated reforms, to realize the vision laid out in the new Strategy for Sustainable Agriculture and Rural Development for 2021–2030 with a Vision to 2050.** There is a need to link productivity growth goals with resource conservation and climate goals and vice versa. For this, institutional policy and process innovations will be needed. Otherwise, the risk is that actions will only enhance efficiency or increase competition through standard market-based approaches or traditional policies and support instruments. Technical change, through research, innovation, and adoption of good practices, has to be placed at the center of public policy and transformation efforts, given their critical role in enabling climate mitigation and adaptation. Decision-making at all scales need to better incorporate risk and uncertainty than in the past, given the increasing frequency, cost, and unpredictability of natural 'shocks' and their contagion effects.
114. **This report highlighted recent interventions in Vietnam's rice production that reduced GHG emissions and input use while also improving productivity and farm incomes.** The analysis suggests that taking these innovations and practices to scale nationally will yield expected environmental and economic benefits without any adverse macro consequences.
115. **To catalyze this green transformation of agriculture, there is a need for a clear and shared vision, objectives, and strategy.** Based on these, it will be possible to design and implement action plans and their M&E. There is a growing compendium of information and best practices on successful agri-environment.

Specific issues to consider relate to the support offered, eligibility conditions, performance evaluation criteria, coordination down to project/program levels, payment distribution (where appropriate), development of relevant information material and training modules, and 'toolkit' for implementation and troubleshooting. Using its own rich experience plus selected international lessons, the government can quickly move the NSGG into full implementation mode.

Table 8: Summary of recommendations for LCT in rice/agriculture

Recommendations	Cost High (H)/Low (L)	Impact High (H)/Low (L)	Prioritization Short (S) or medium term (M)
A. Ensuring policy coherence and plan-budget alignment for the LCT			
Ensure close alignment of sectoral plans and targets with the NSGG and international commitments.	L	H	S
Ensure plan-budget alignment for LCT goals, so that public resources are deployed more effectively to implement planned priorities.	L	H	S
B. Repurposing policy tools and public expenditure to support LCT			
B.1. Market-based instruments			
Incentivize efficient water use, including expanding pay-for-service principle (cost recovery in irrigation) to reduce overuse of water and promote operations and maintenance.	M	H	M
Revise or consider phasing out any support on fertilizers to reduce distortions and perverse incentives, thereby limiting fertilizer overuse and promoting healthier plant nutrient management.	L	H	S
Design and pilot programs to levy fees or taxes on environmentally damaging inputs.	L	H	M
Assess and take needed measures to support well-functioning input and output markets.	L	H	M
Review tariff and non-tariff barriers and export subsidies on food and agriculture products to examine their potential impact on sustainable resource use and environmental concerns, such as biodiversity.	L	H	M
Proactively support international value chains to meet the demands for greener products, along with the associated conditionalities (including standards and certification).	L	H	M
Improve enforcement of environmental regulations and standards and certification from the farm gate to the retail sector.	L	H	S
Along with other key emitting sectors, the government should put in place measures for introducing carbon pricing in agriculture, including in rice production to expedite the transition towards low-carbon rice.	H	H	M
B.2. Regulatory instruments			
Remove/reduce legal, regulatory, and administrative barriers to allow more flexible land use, especially for the large areas of designated paddy land, and foster a more active land market.	L	H	H

Recommendations	Cost High (H)/Low (L)	Impact High (H)/Low (L)	Prioritization Short (S) or medium term (M)
Encourage and facilitate land consolidation by (a) increasing the current ceiling on landholding sizes and (b) setting up a market for transferring LURs, with transparent rules and low administrative costs.	L	H	M
Guarantee land tenure rights.	L	H	M
Improve land valuation and land economics by (a) establishing a land valuation authority and (b) requiring that certified appraisers/valuers undertake valuations for all purposes.	L	H	M
Improve enforcement of environmental regulations and standards and certification from the farm gate to the retail sector.	L	H	S
Enact and incentivize compliance with controls to reduce excessive use of agrochemicals and fertilizers.	L	H	M
Implement and strengthen agreements for biodiversity, forests, water, and soil quality.	L	H	S
Consider mechanisms for payment for environmental services and carbon emissions trading to establish the basis for protecting and restoring forests and other ecosystem services and proactively position Vietnam to favorably benefit from the expected boom in international market for carbon offsets.	M	H	M
B.3. Repurpose and refocus public expenditures			
Repurpose agricultural subsidies on inputs (water, fertilizer, and so on) toward adoption of resilient agriculture production practices.	L	H	M
Repurpose public expenditure in agriculture toward development and adoption of 'less GHG emitting' crop varieties and production technologies.	L	H	S
Refocus public expenditures on R&D and dissemination of new, low-carbon technologies (such as climate-resilient seed varieties, water-saving technologies, improved post-harvest technologies, and other value chain infrastructure), including through grants and tax credits with relevant public and private partners.	H	H	M
Invest in data systems and digital technologies (for example, public use datasets on agriculture production, digital farmer registry, and digital payment infrastructure) to accelerate the transition to low-carbon agriculture.	H	H	S
Invest in and scale up networked systems and technologies (AWD, IoT, SCADA, ³⁸ and so on) to reduce emissions in rice production.	L	H	M
C. Promoting investment in low-carbon rice/agriculture			

38 SCADA = Supervisory control and data acquisition.

Recommendations	Cost High (H)/Low (L)	Impact High (H)/Low (L)	Prioritization Short (S) or medium term (M)
Enhance investment capacity at the farmer level by improving financial literacy and promoting other forms of collateral besides land (for example, as structures, equipment, commodity inventories, and receivables).	M	H	M
Facilitate digital financing in agriculture by enabling growth of digital platforms and new methods of calculating digital credit scores, especially for seemingly 'un-bankable' smallholder farmers.	M	H	M
Improve access to finance for smallholder agriculture by removing caps on bank lending and permitting warehouse receipts and crops stocks to serve as collateral.	L	H	M
De-risk private sector investments in low-carbon agriculture by improving agricultural risk insurance schemes.	L	H	S
Reduce risk premiums by (a) investing in innovative insurance products that adopt a risk layering approach, (b) invest in the development of insurance products that bundle insurance with credit and/or improved seeds/fertilizers, and (c) repurposing insurance premium subsidies to low-carbon crops and practices.	L	H	M
Mobilize blended finance to de-risk investments in low-carbon agriculture by (a) building the capacity of relevant stakeholders on available blended finance facilities put in place by multilateral development banks, (b) developing national guidelines for tapping into these facilities, and (c) developing an institutional framework for the private sector to access additional resources through the emerging carbon market.	L	H	S
D. Institutional strengthening			
Strengthen the extension capacities for green, low-carbon agriculture and ensure that capacity needs in the form of training and information are met.	L	H	S
Strengthen MARD's and DARD's capacity to monitor the environmental impacts of policies and investments through (a) establishing Environment Divisions within MARD and DARD (currently, only the Department of Livestock Production has an Environment Division) and (b) training MARD and DARD staff on the using advanced digital technologies to monitor environmental impact.	L	L	S
Incorporate sustainable approaches in training, education, and advice programs throughout the entire food chain.	L	H	S
Promote use of digital and remote sensing tools, technologies, and data systems for more accurate and timely monitoring and assessment of environment and natural resources.	L	H	S
Strengthen institutional coordination and collaboration between MARD and other relevant ministries and provinces/other sector ministries implementing agricultural programs.	L	H	S

Recommendations	Cost High (H)/Low (L)	Impact High (H)/Low (L)	Prioritization Short (S) or medium term (M)
MARD and the Ministry of Finance (MOF) need to establish a carbon fund that can be used to receive the payments for certified carbon abatements and develop a mechanism for delivering those funds to farmers who participate in the carbon abatement programs.	L	H	S
E. Enabling the private sector and other stakeholders			
Leverage digital technologies and platforms (for example, sensors, e-platforms, and blockchain) to facilitate end-to-end traceability in supply chains, increasing consumer trust, and allow niche markets with favorable price premiums to develop.	M	H	M
Establish technology funds and associated protocols to support green entrepreneurs, especially among the younger (millennial) and more tech-savvy farmers.	M	H	M
Strengthen farmer cooperatives' capacity through training programs (technical, managerial, accounting, legal, and regulatory), accreditation schemes, and so on and by providing tax and other financial incentives to businesses to work with cooperatives.	M	H	M
Support farm clusters and 'horizontal' integration to enhance coordination, collective action, and economies of scale.	L	H	S



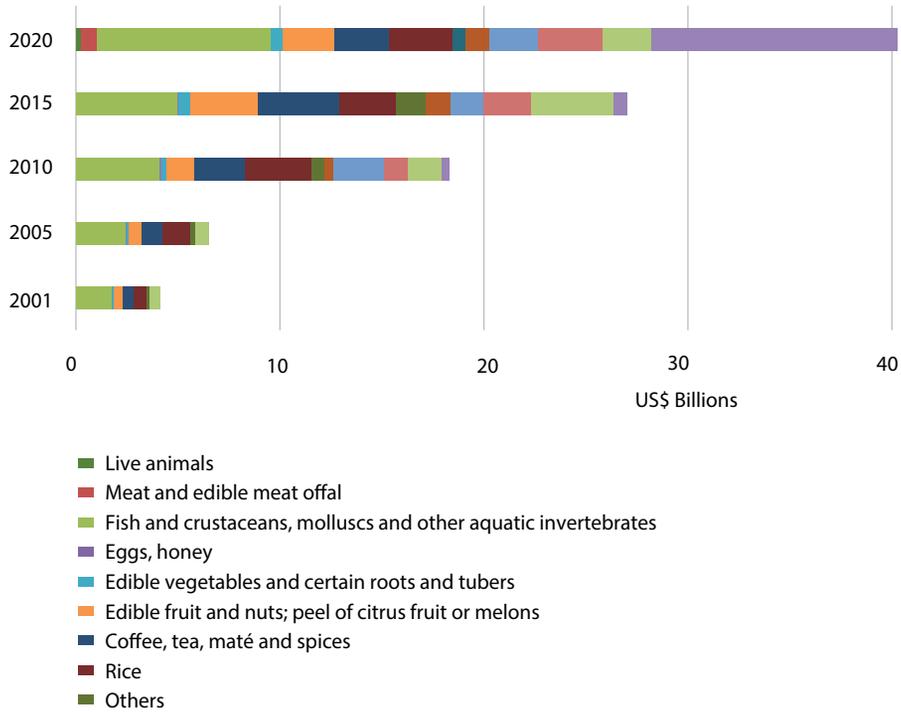
APPENDIX 1

SUPPLEMENTAL INFORMATION³⁹

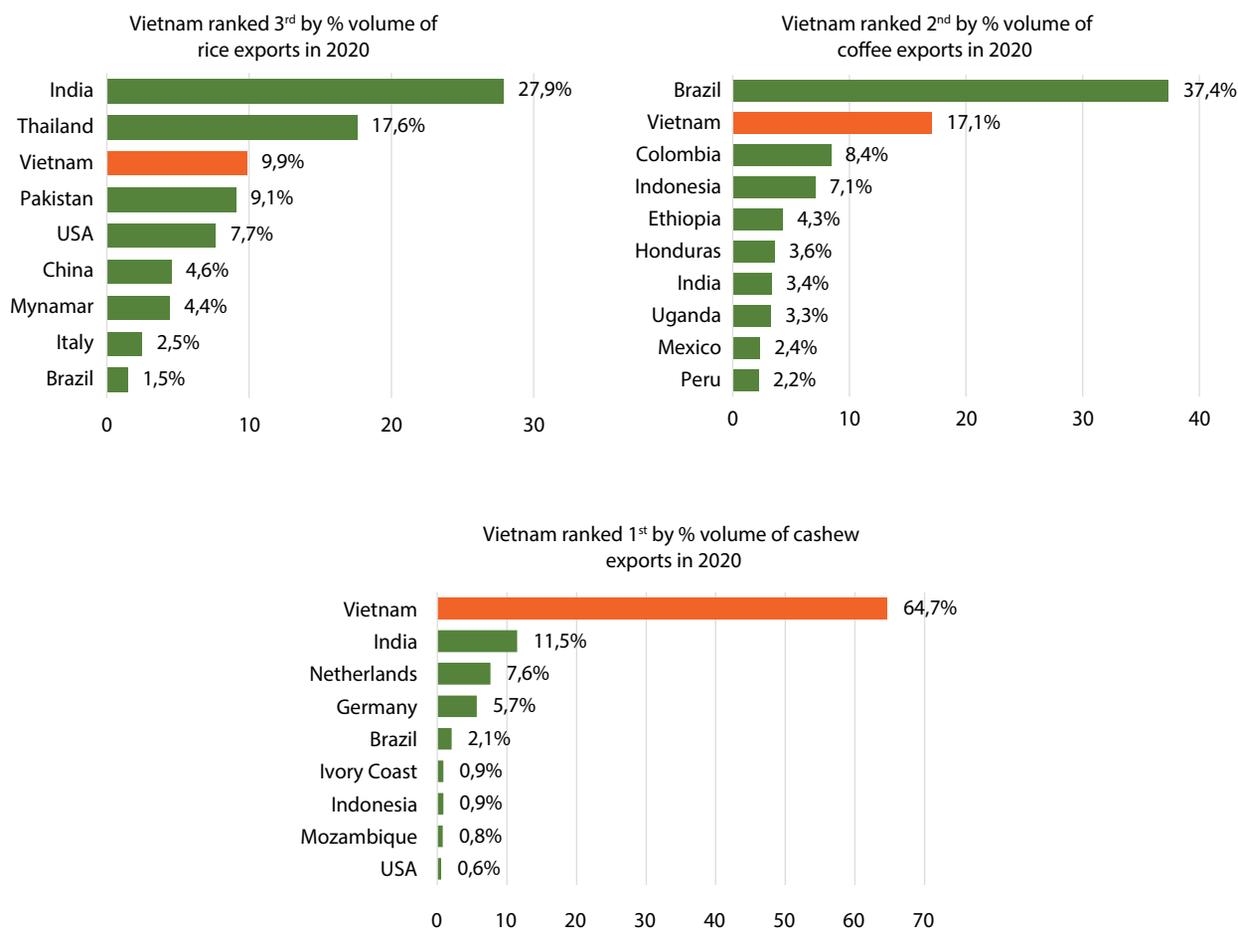
³⁹ This Appendix provides supplemental information in both written and graphic form.

STRUCTURE OF VIETNAM'S AGRICULTURAL EXPORTS

Figure A1.1: Vietnam's agricultural exports (US\$, billions)

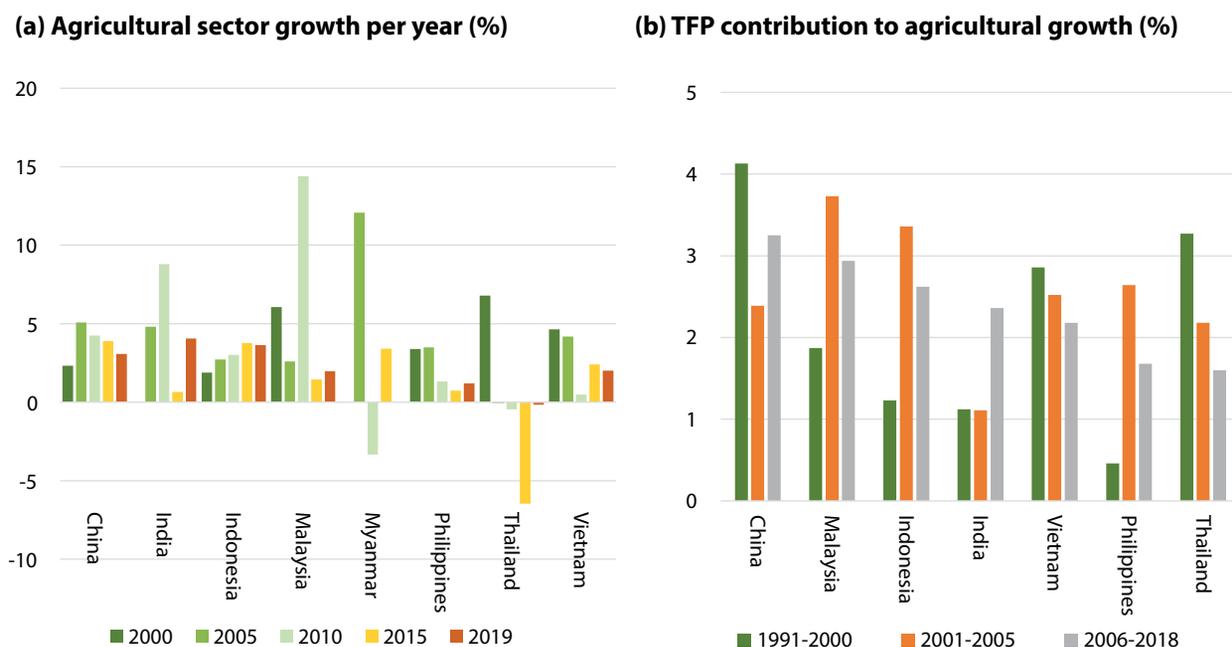


Source: Vietnam's export value (Government Statistical Office [GSO]).

Figure A1.2: Vietnam's share of rice, coffee, and cashew exports by percentage of volume

TOTAL FACTOR PRODUCTIVITY

1. **TFP growth in Vietnam has been lower than elsewhere in the region since the mid-2000s.** From 2001 to 2010, TFP accounted for 57 percent of Vietnam's agricultural growth, while TFP's share of agricultural growth in Thailand, China, and Malaysia was 83, 86, and 92 percent, respectively. The TFP growth rate for Vietnam was 2.86 percent from 1990 to 2000, increasing to about 3.36 percent in mid-2000 and declining again to 2.18 percent by 2018 (Figure A1.3).

Figure A1.3: Vietnam's agricultural sector growth compared to other countries in the region

Source: Based on data from WDI.

VIETNAM - RICE PRODUCTION BALANCE SHEET FROM 1995 TO 2020

Table A1.1: Vietnam's rice production balance sheet from 1995 to 2020

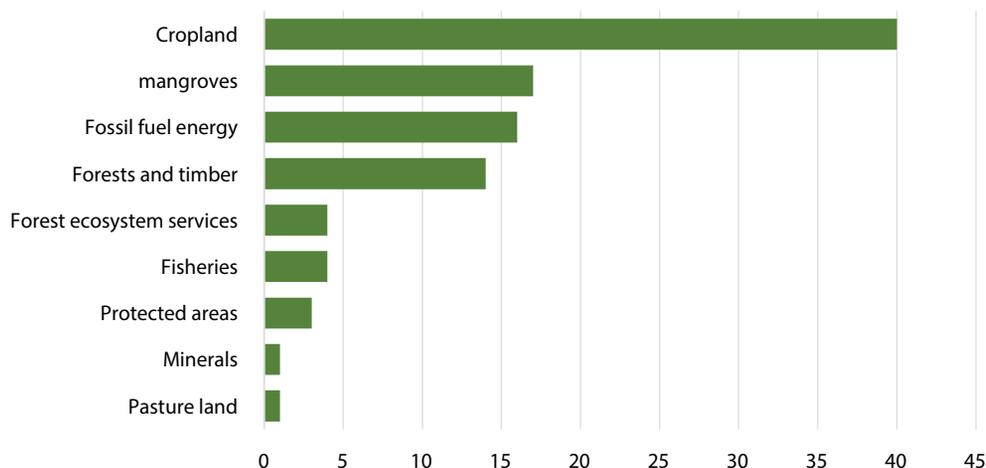
	1995	2000	2010	2015	2019	2020
Population, million people	72.00	79.91	87.97	92.68	96.48	97.58
Paddy production, million tons	24.96	32.53	40.01	45.09	43.45	42.77
Rice area, million hectares ^c	6.77	7.67	7.49	7.83	7.47	7.28
Milled rice eq. million tons	13.90	21.25	26.37	28.41	28.18	27.74
Rice per capita consumption, kg/year	142.00	149.40	116.20	105.60	96.60	95.80
Rice non-food use, million tons ^a	1.69	4.62	9.84	11.95	13.03	12.65
Rice consumption, million tons ^b	11.91	16.56	20.07	21.74	22.35	22.00
Rice surplus, million tons	1.99	4.69	6.31	6.67	5.83	5.74
Rice exports, million tons	1.99	5.86	6.89	6.58	6.37	6.25
Rice export values, US\$, billions	0.53	0.67	1.41	3.25	2.62	3.12
Agricultural Value added, US\$, billions	5.70	7.70	11.10	21.30	32.80	39.80
Rice export percentage of agricultural value added	9.30	8.70	12.70	15.30	8.00	7.80

Source: World Bank staff estimates using GSO and MARD data.

Note: a. Includes industrial use, stock of farmers and the state, and post-harvest losses; b. Includes food and other uses; c. Paddy area sown.

2. **Vietnam's vision for green growth is preserving its natural capital, especially the productivity of its agricultural landscape.** Agriculture, crop, and pastureland together account for the largest share of Vietnam's natural resource wealth at 43 percent. Forest resources account for approximately 20 percent of Vietnam's natural wealth, and among the many alternative forest uses, protected areas are only 4.3 percent (Figure A1.4).

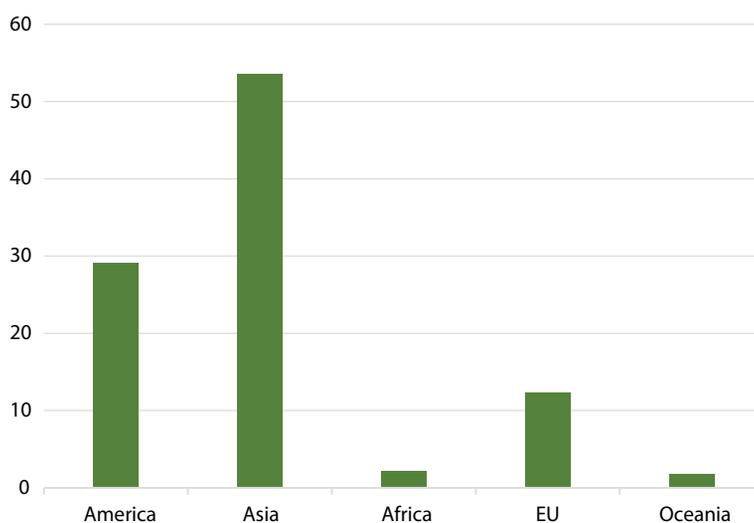
Figure A1.4: Vietnam's natural capital



Source: World Bank 2021b.

VIETNAM'S MAIN AGRICULTURAL EXPORT DESTINATIONS BY PERCENTAGE VALUE IN 2020

Figure A1.5: Vietnam's main agricultural export destinations by percentage value in 2020

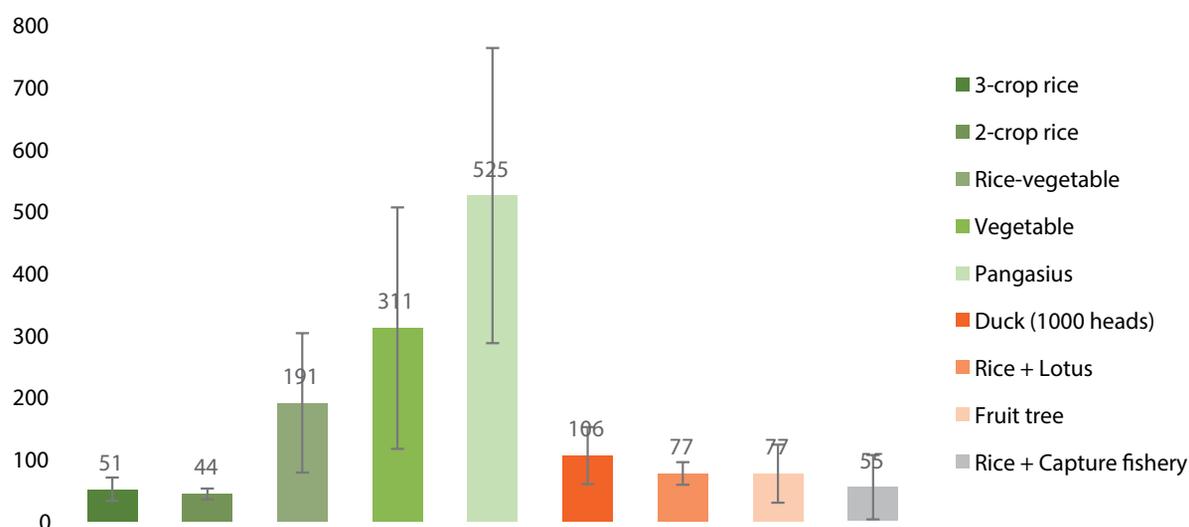


THE NATIONAL STRATEGY ON CLIMATE CHANGE AND VIETNAM GREEN GROWTH STRATEGY

3. **Within the NSGG, the orientations for agriculture include the following:** (a) formulating and implementing tasks to develop an efficient, sustainable, low-emission, climate-smart, and resilient commodity agricultural sector, toward a circular economy; (b) developing and implementing programs and projects to protect and restore ecosystems and biodiversity in agriculture, forestry, and fisheries and increase carbon sequestration; (c) promoting market links in product value chains and improving competitiveness of green, safe, and organic agricultural products, meeting international and domestic standards; and (d) accelerating the new rural development in a green and sustainable direction with more communes meeting new rural development criteria.

RICE NET MARGINS AND INCOME

Figure A1.6: Rice net margins per hectare in VND, millions, compared to other MKD crops



Source: World Bank and IPSARD 2020 - based on the VHLSS data (2018).

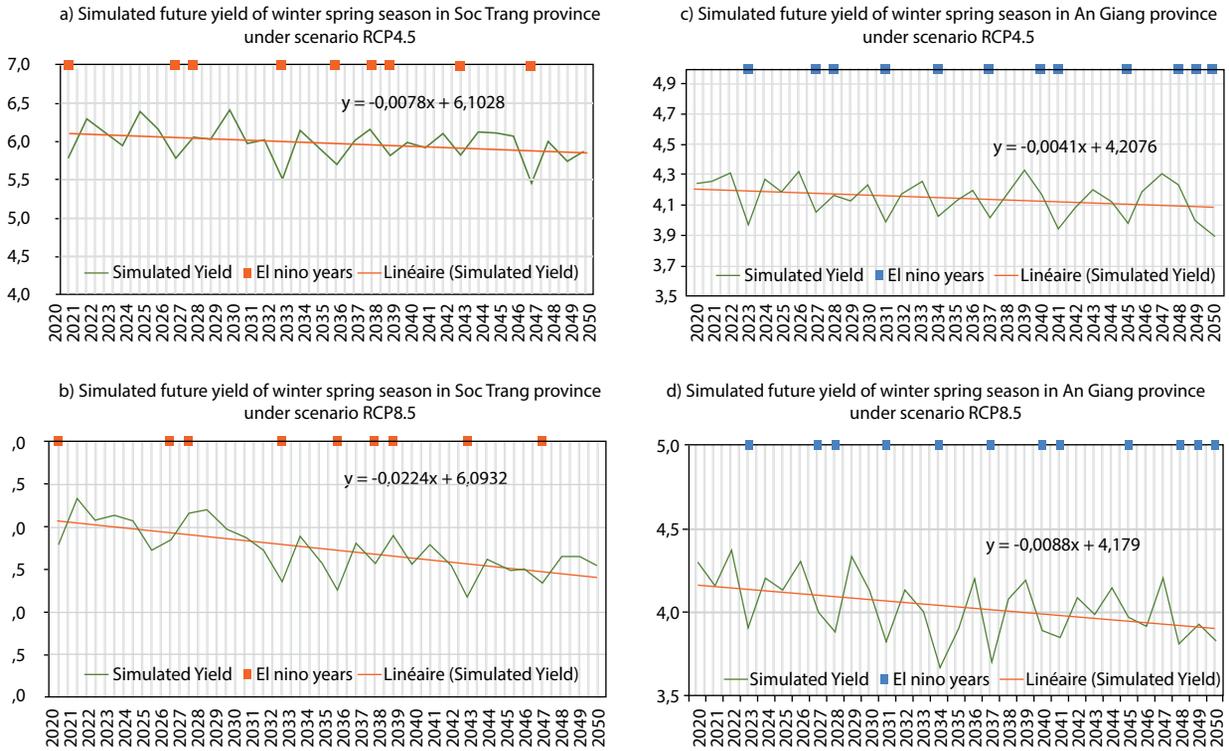
Table A1.2: Average national gross income per household per hectare by commodity and region (VND, millions)

	Paddy	Other annual crops	Perennial crops	Livestock	Fishery/aquaculture	All commodities
Red River Delta	6,492	5,498	2,290	42,554	21,223	43,359
Northern Midlands and Mountain	5,699	5,862	5,370	23,319	6,618	43,362
North Central and Coastal	5,702	4,322	4,597	21,943	17,490	37,163
Central Highlands	3,702	7,258	42,914	28,120	3,124	69,052
Southeast	3,373	7,024	44,002	42,887	35,281	74,417
MKD	26,932	5,766	18,694	36,264	33,728	76,695
Vietnam	8,763	5,531	11,688	29,273	20,860	51,035

Source: Estimates based on the 2018 VHLSS data.

CLIMATE CHANGE IMPACTS

Figure A1.7: Simulated rice yield for winter and spring seasons in selected provinces of the MKD



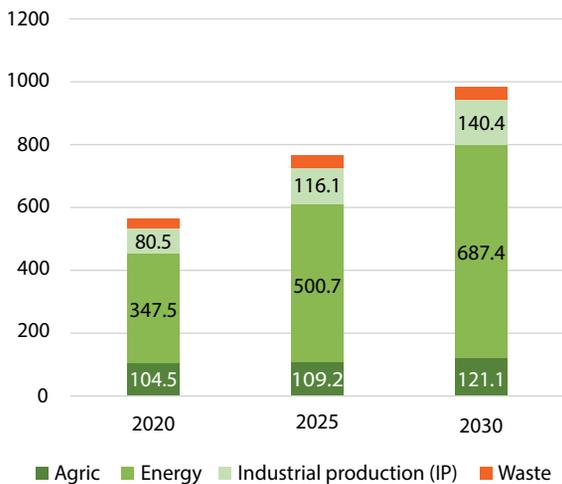
Source: AFD 2021.

Note: Red dots indicate El Niño year, while blue dots indicate La Niña years.

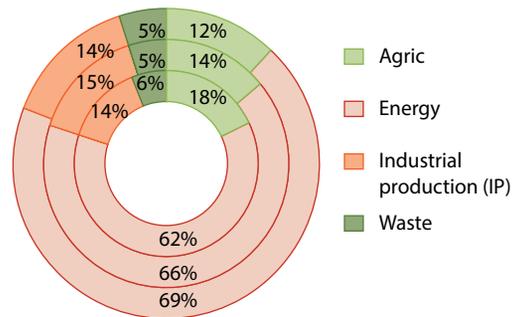
SOURCES OF GHG EMISSIONS IN VIETNAM

Figure A1.8: Total emissions in millions tCO₂e and contributions by key sectors (%)

(a) Total emissions (million tCO₂e)

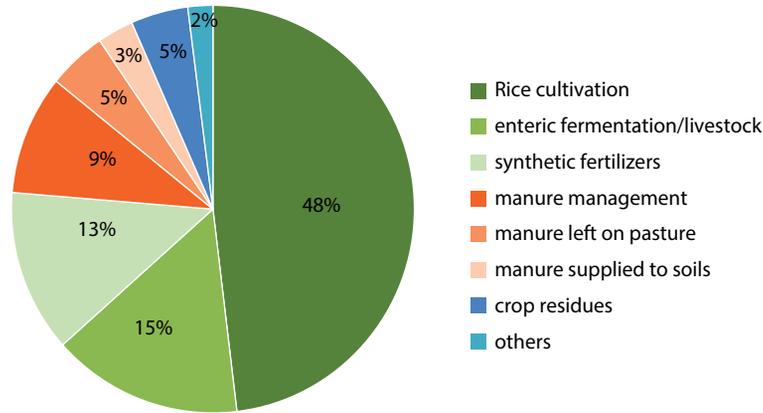


(b) Emission contributions by key sector (%)



Source: IPCC and FAOSTAT.⁴⁰ <https://www.ipcc.ch> and <http://www.fao.org/faostat/en/#country/237>

Figure A1.9: Vietnam sources of agricultural GHG emissions (%)



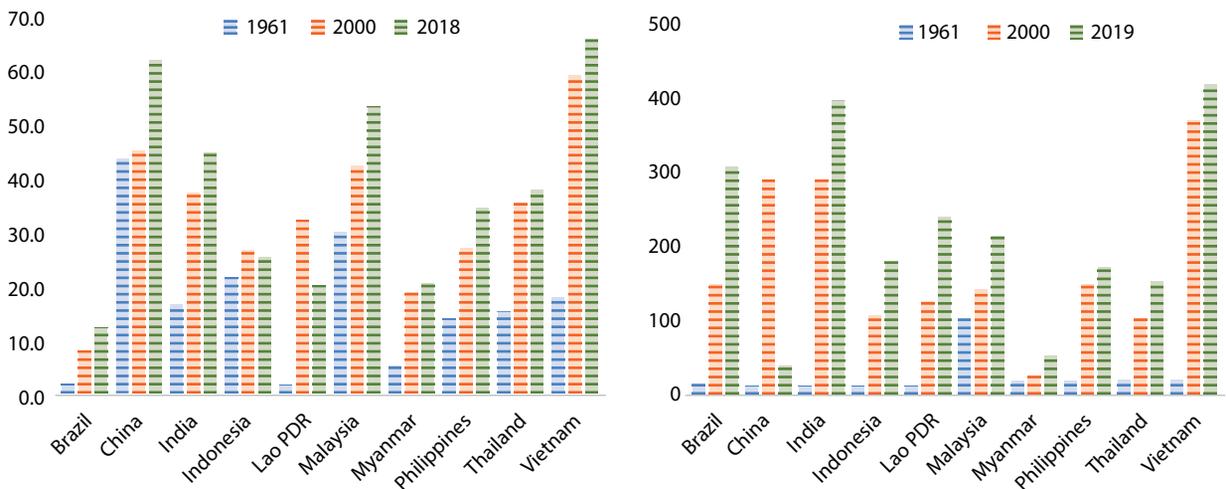
Source: FAOSTAT. <http://www.fao.org/faostat/en/#country/237>.⁴¹

FERTILIZER AND WATER USE INEFFICIENCY

Figure A1.10: Irrigated land, percent of arable land; Average use of NPK fertilizer in kilograms per hectare

(a) % of arable land that is irrigated

(b) NPK application, kg/ha



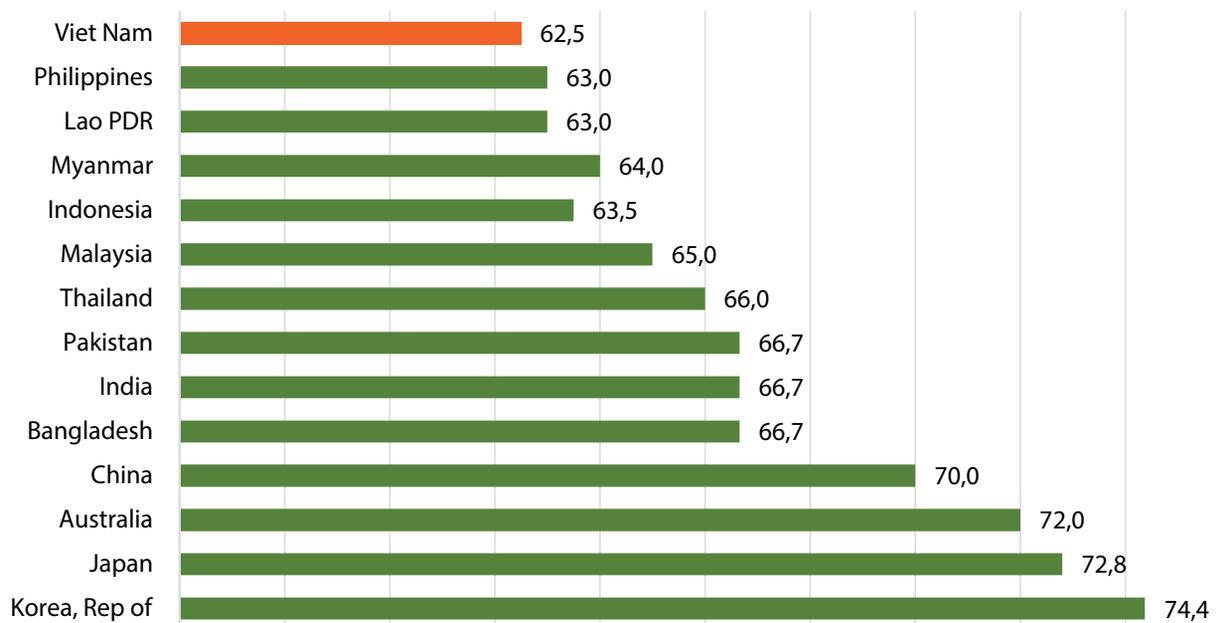
Source: Estimates based on FAOSTAT 2020 (<http://www.fao.org/faostat/en/#data>).

40 There are slight differences in the figures on agricultural emissions depending on the source of the data. In this report, we consistently use the data from IPCC, FAOSTAT, and the government as presented in the NDC (2020).

41 EDGAR-Food puts the total figure for food system emissions for Vietnam at 176,652 ktCO₂e. https://edgar.jrc.ec.europa.eu/edgar_food#data_download (see the Excel data files). If the total emissions from the agri-food system include other aspects beyond primary production, the total emissions are significantly higher.

EXAMPLE OF VIETNAM'S INEFFICIENCY IN RICE MILLING

Figure A1.11: Rice milling efficiency in 2021 (%)

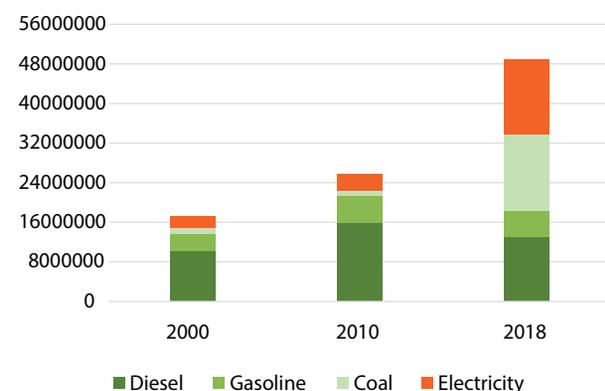


Source: USDA 2021.

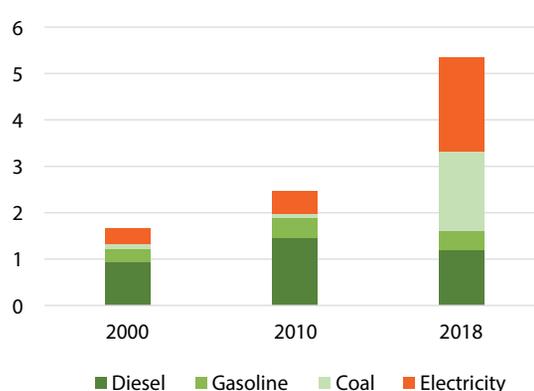
EMISSIONS FROM ENERGY USES IN AGRICULTURE IN VIETNAM

Figure A1.12: Agricultural energy uses and emissions in Vietnam

Energy sources used in agriculture in Vietnam, million KJ



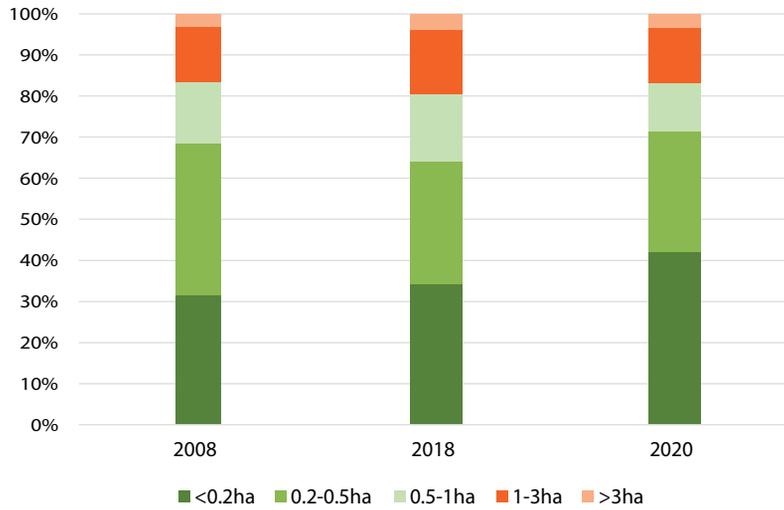
Emissions from energy use in agriculture in Vietnam, million tCO₂e



Source: IPCC (<https://www.ipcc.ch>); FAOSTAT (<http://www.fao.org/faostat/en/#country/237>).

AGRICULTURAL LAND FRAGMENTATION IN VIETNAM

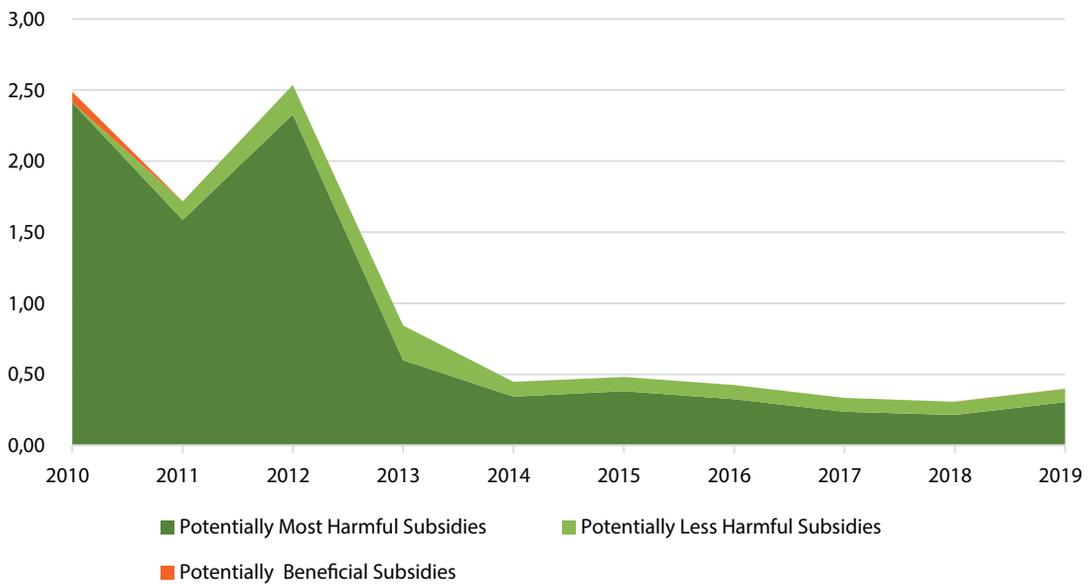
Figure A1.13: Agricultural land fragmentation in Vietnam



Source: Estimates based on the 2018 VHLSS data.

PRODUCER SUPPORT FOR AGRICULTURE IN VIETNAM

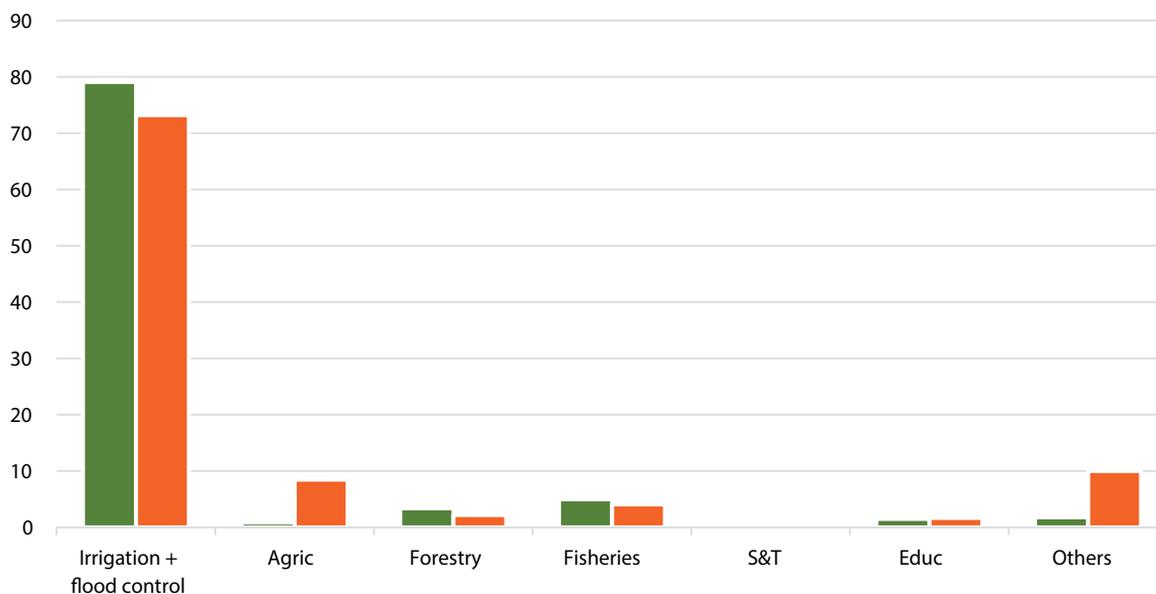
Figure A1.14: Evolution of producer support for agriculture in Vietnam from 2010 to 2019 (US\$, billions)



Source: OECD database (<https://data.oecd.org>).

PUBLIC SECTOR AGRICULTURE SPENDING IN VIETNAM

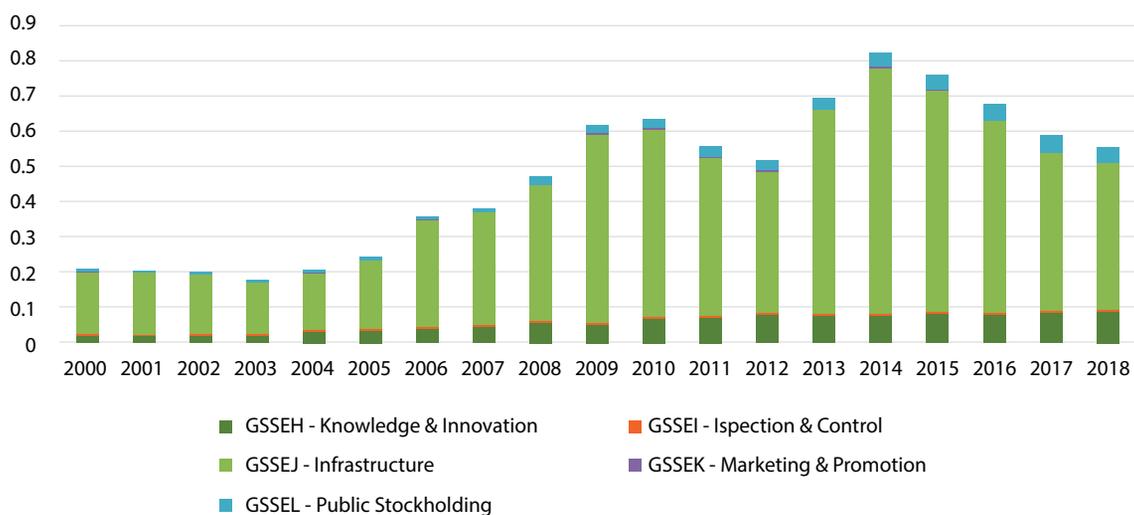
Figure A1.15: Structure of public sector spending on agriculture in Vietnam from 2016 to 2020



Source: World Bank 2021. Review of MARD’s spending.

GENERAL SERVICES SUPPORT ESTIMATES

Figure A1.16: Composition of general services support estimates for agriculture between 2000 and 2018



Source: OECD database.



APPENDIX 2

ACTIONS TO 'GREEN' RICE PRODUCTION

1. There are many options to vastly improve productivity within Vietnam's rice sector that reduce emissions and are more environmentally sustainable. The suggestions below range from actions that are focused on reducing emissions to a variety of different actions to be taken within the sector, use of digital technologies to the SRP (focused on voluntary standards), specific actions in a recent review of CSA in Vietnam with recommendations for rice, and collective action among rice producers. The variety of options show that there are pathways to greatly improve green rice production in Vietnam, and most of these actions are complementary to AWD and 1M5R.

IMPROVING RICE STRAW MANAGEMENT

2. **Reducing the burning of rice straw and other residues is critical to reduce the negative environmental impact of the sector and reduce overall emissions of GHGs.** As shown in Figure 10 in Chapter 3, straw burning tends to increase emissions even when AWD is applied. Farmers, however, do not have the financial incentives and training on improved rice straw management and the market for rice residue products (such as fertilizer, animal fodder, biofuel, or bioplastics) is limited. Sustainable practices would suggest leaving rice straw on the field to supplement organic matter. But if fields are to be inundated with water, then the sustainable option is to remove it (and not burn it) so that it will not rot and release methane. For instance, in An Giang Province, the adoption of straw removal (and subsequent straw use) reached almost 28 percent of rice land in 2019 (about 174,000 ha), reducing straw burning and further saving GHG emissions. This rate would reach an estimated 36 percent by 2025 through reduced burning.⁴² Yet, capacity building and market incentives are needed to encourage more widespread adoption of these practices, such as creating new applications and revenue streams for rice straw products.

RICE VALUE CHAIN IMPROVEMENTS SUPPORTING AN LCT

3. **Vietnam needs to improve its efficiency in rice value chains, reduce losses and waste, and reduce emissions.** For example, the international best practice standard for milling is an efficiency of about 67–70 percent. Increasing Vietnam's milling efficiency by 8 percent, from 62 to 70 percent, would save about 3.5 million tons of rice that could be available for consumption or exports and generate GHG savings equal to about 3.15 million tCO₂e GHG emission annually, assuming an intensity of 0.9 kg GHG emissions per kg of paddy.⁴³ This would require investing in adequate drying facilities at the farm level to reduce the moisture content from about 27 percent to 14 percent and transporting dried paddy (lower weight) to the mill.

GREENING ENERGY USE IN AGRICULTURE

4. **Vietnam could make major gains in reducing rice sector emissions by reducing the energy intensity and promoting renewable energy in agriculture.** As shown in Figure A1.12 in Appendix 1, there is an increase in the use of nonrenewable fossil fuels, including coal. Estimates of energy intensity-related emissions in agriculture have been increasing from around 1.5 million tCO₂e in 2000 to slightly more than 5 million tCO₂e in 2018. To date, using renewable energy sources such as solar is limited in agriculture. In rice production, energy intensity is high in irrigation and drainage, post-harvest handling, and rice milling. The use of less efficient water pumps and rice milling equipment contributes to emissions. During the dry

42 CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS): <https://www.cgiar.org/annual-report/performance-report-2020/low-emission-technologies-transform-vietnams-rice-sector/>

43 The Initial Biennial Update Report of Viet Nam to the United Nations Framework Convention on Climate Change (2014), <https://unfccc.int/resource/docs/natc/vnmbur1.pdf>; The Third Biennial Updated Report of Viet Nam to the United Nations Framework Convention on Climate Change (2020), https://unfccc.int/sites/default/files/resource/Viet%20Nam_BUR3.pdf.

season, farmers use power pumps to irrigate their fields because the water level in the irrigation channels is lower than in the soil surface of the paddy field, particularly in the MKD. High-efficiency water pumps can reduce total energy usage and save costs while providing maximum irrigation and drainage capacity.

ALTERNATIVE WET AND DRY SYSTEM OF RICE IRRIGATION

5. **Conventional rice production requires three to five times more water than other cereals.** AWD is a water-saving and eco-friendly option (Ishfaq et al. 2020). AWD requires 25–70 percent less water than conventional systems without yield reduction. AWD reduces GHG emission and restricts arsenic (As) and mercury (Hg) accumulation in rice grains. Global warming and declining water resources are threatening the sustainability of rice production and global food security. The conventional CF system of rice production is a major contributor to rice production, but it requires a huge amount of water input and poses a severe threat to the ecosystem due to emission of GHGs and accumulation of heavy metals (for example, As and Hg) in the rice grains. The declining soil health, increasing micronutrient deficiencies, and declining organic matter are also threatening the long-term sustainability of the conventional rice production system. In this scenario, the AWD irrigation system is a promising, water-saving, economically viable, and eco-friendly alternative to the CF system. In this review, we discuss the influence of AWD on nutrient dynamics, rice growth, yield formation, grain quality, water use efficiency, emission of GHGs, and economics in comparison with the CF rice production system.
6. **Overall, AWD irrigation techniques can reduce the total water inputs (25–70 percent) and emissions of CH₄ (11–95 percent), As (13–90 percent), and Hgs (5–90 percent) in rice grains** while maintaining similar or better paddy yield (10–20 percent) than the CF system depending upon weather conditions, soil type, degree of dryness, crop duration, and crop growth stage. The mild-AWD system improves the rice grain quality by reducing the kernel chalkiness (40 percent) and increasing the head rice recovery (6 percent) and concentration of grain micronutrients (such as zinc). The AWD system is being adopted in all major rice-producing regions but not widely, possibly due to complicated interrelations of agricultural and socioeconomic systems and lack of institutional support.

USING DIGITAL TECHNOLOGIES

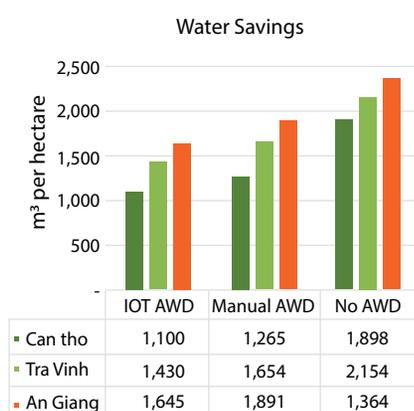
7. **Digitalization of agriculture is using digital technologies, innovations, and data to transform agri-business processes, models, and practices across the full spectrum of agricultural value chains.** Data-driven farming and operations along the agricultural value chains entail improving the decision-making processes in crop production by providing timely and robust data to provide insight into what, where, and when to plant, process, and supply. By leveraging digital technologies to support farmers, Vietnam's agricultural output could grow through improved productivity, value added, quality, and environmental sustainability across supply chains. An excellent summary of digital agriculture in Vietnam is in the Digital Agriculture Profile (Burra et al. 2021).

Figure A2.1: Use of the IoT in AWD for rice in the MKD and coffee in the Central Highlands of Vietnam - Early evidence of successes at the farm level

Water savings: Using IoT AWD in rice reduces water use by 42% compared to non-AWD farming (CF irrigation)

GHG emissions: 60–70% reduction (4–6 tCO₂e/ha/crop)

Farmer production cost: 22% less



Yields: increase by 24%

IoT in Coffee in Central Highlands

IoT on coffee yields same encouraging results on water, energy, and labor savings, but GHG reduction has not been measured



Source: Choudhary and Fock 2020 (rice) and MimosaTEK 2019 (coffee).

OPTIONS FOR EMISSIONS ABATEMENT IN VIETNAM

8. **McKinsey (2020a) identified 25 options for achieving significant GHG emission reduction in rice and prioritized them based on their abatement potential and the abatement cost per tCO₂e mitigated.** Of these options, 15 are highlighted in Table A2.1. Seven of these prioritized options focus on rice production practices—and are all applicable—and most have been applied (on a much smaller scale) in Vietnam.

Table A2.1: Options for emission abatement - International perspectives

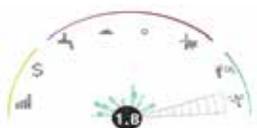
Potential measure/options (additional list for rice)	GHG abatement potential (million tCO ₂ e)	Abatement cost (US\$/tCO ₂ e)
Adopt zero-emission on-farm machinery and equipment	537	229
Reduce nitrogen overapplication in China, India, and most of East Asia	88	97
Expand adoption of dry seeding in rice cultivation	217	41
Scale low and no-tillage practices	119	41
Improve paddy water management	296	12
Improve fertilization practices in rice cultivation	449	3
Expand adoption of controlled-release and stabilized fertilizers	75	65

Source: McKinsey 2020a (based on FAO database).

DIVERSIFYING TO AQUACULTURE AND OTHER CROPS

9. **Diversifying from rice to aquaculture and other crops such as fruits and vegetables has the potential to raise farmers' incomes compared to mono-culture rice production, based on analysis by World Bank and IPSARD (2020).** For instance, mono-rice farming profits are VND 40–50 million per ha per year compared to more than VND 500 million per ha per year for Pangasius fish farming, VND 350 million per ha per year for vegetables, VND 140 million per ha per year for fruit trees, and VND 100–110 million per ha per year for rice-vegetables/rice-aquaculture models. Looking at employment generation, rice-farming systems require the least labor (40–60 person-days per ha per year) compared to Pangasius fish farming, vegetable, and fruit tree models (around 600, 380, and 330 person-days per ha per year, respectively). The analysis further shows that around 450,000–550,000 ha of MKD rice land could be converted to alternative uses or rice, other crops, and aquaculture rotations without having much impact on the region's overall rice surplus. This offers an opportunity for enormous growth and transformation while being environmentally beneficial and reducing emissions from rice intensification in unsuitable areas.

Figure A2.2: Detailed smartness assessment for top ongoing CSA practices by production system as implemented in Vietnam

CSA practice	Region and adoption rate (%) <30 30-60 60>	Predominant farm scale S: small scale M: medium scale L: large scale	Climate smartness	Impact on CSA Pillars
Rice (77% of total harvested area)				
System of Rice Intensification-SRI (AWD, early planting, reduced plant density, fertilizer application)	Red river delta 30-60%	S		Productivity Increase yield. Adaptation Increase resistance to unfavorable condition: drought, flood, disease. Mitigation Mitigate GHG emissions.
	Mekong river delta 30-60%	S		
Use of flood-resistant varieties	Nothern mountain 60%>	M		Productivity Increase land and crop productivity per unit of water. Adaptation Increase resistance to heavy rains or flood. Mitigation Provide moderate reduction in GHG emissions per unit of food produced.
	Red river delta 60%>	S M L		

Source: Vietnam Climate-Smart Agriculture in Viet Nam. Country Profile, page 14. https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA_Profile_Vietnam2.2.pdf.

COLLECTIVE ACTION AMONG RICE PRODUCERS: EXAMPLES FROM OTHER SOUTHEAST ASIAN COUNTRIES

10. **A decade ago, in southern Cambodia, farmers adopted joint farming of their paddy plots to overcome a major production issue.** At that time, it was difficult for agricultural machinery (combine harvester for paddy) to access certain fields—farmers planted different varieties of rice at different times, and accessing a farmer's plot would have required driving the combiner over the growing crop of the neighboring farmer. To solve this issue, farmers agreed to synchronize the planting of their crops. This joint action not only made the harvest smoother but also resulted in the aggregation of production and the ability to sell paddy in bulk.
11. **Another joint farming experience has been applied by the Nepal Agriculture Cooperative Central Federation, where rice farmers pooled their resources and land under a central management unit.** Under this arrangement, neighboring farmers lease their land to the federation for 15 years and work on the joint plot (70 ha) and receive wages according to their work. The Philippines adopted a similar experience for Sugar Cane Block Farming in 2011 to encourage neighboring farmers to farm their plots (from tilling to harvesting) jointly. Similar experiences exist in parts of India and Indonesia.
12. **China supported farm mechanization and outsourcing of production functions as a way to increase the productivity of land and other inputs.** To do so, the Chinese government proposed equipment-sharing arrangements such as joint ownership, leasing, and farming services through the development of now widely used combined service enterprise clusters. Specifically, the Chinese government subsidized the prices of machine and warehouse space, exonerated service enterprises from road tolls, improved roads, and offered market intelligence such as harvest calendars that helped them develop viable service areas across multiple provinces. The government also helped entrepreneurs develop cooperative relationships to share the costs of maintenance and better coordinate their service areas. The services provided by these companies have been critical, especially in the context of shortage of labor and increasing labor costs (World Bank 2021c).

SUSTAINABLE RICE PLATFORM

13. **The SRP Standard for Sustainable Rice Cultivation is the world's first voluntary sustainability standard for rice.** The SRP is a global multistakeholder alliance launched in 2011 and led by UN Environment, IRRI, and GIZ, comprising over 90 institutional stakeholders, including public and private sector stakeholders, research and financial institutions, and NGOs (see Box 4 in chapter 4 for details). The SRP promotes resource use efficiency and climate change resilience in rice systems (both on-farm and throughout value chains) and pursues voluntary market transformation initiatives by developing sustainable production standards, indicators, incentive mechanisms, and outreach mechanisms to boost wide-scale adoption of sustainable best practices throughout rice value chains. The SRP's goal is to minimize environmental impacts of rice production and consumption while enhancing smallholder incomes and contributing to food security.
14. **The SRP is one of the large-scale global models meant to address the key challenges in the rice supply chain—to ensure that it is produced in an environmentally sustainable manner.** This is in view of the fact that rice is integral to global food systems. Worldwide, 3.5 billion people consume rice, and 144 million family farmers produce rice. Tragically, some 90 percent of them live in or near the poverty line—many of them are women. As the population grows, so does the demand for rice. Meeting a growing demand poses an enormous challenge in a world with finite resources. In addition, rice smallholders bear the health and economic risks of production as they are inadequately equipped to safeguard their livelihood against

climate change impacts and market risks. The key challenges being addressed by the platform include the following: (a) one out of four farmers in the world is a rice smallholder, who earns on average US\$2–7 per day from rice; (b) irrigated rice cultivation uses 30–40 percent of the world’s freshwater and is responsible for 10 percent of global man-made methane emissions; (c) rice production is a leading cause of habitat loss, in both wetlands and forests; and (d) global rice consumption is projected to grow 13 percent from 2018 to 2027, requiring 500 million tons of milled rice annually.

15. **In Vietnam, only 8 percent of the rice farmers have been able to meet the SRP standards.** Some of the large-scale rice supply chains, such as Olam International (a global agri-business which is also a member of the Better Rice Initiative Asia), are working with almost 3,000 farmers and intends to reach 10,000 smallholder rice farmers by 2022 in Vietnam’s MKD region, to increase production in a sustainable way and secure long-term supply.
16. **The SRP standard presents an opportunity for scaling up low-carbon rice production techniques.** It provides an agreed standard and a foundation of metrics upon which finance innovations can be developed. The SRP provides a mechanism to improve the flow of finance to sustainable practices in the rice value chain based on public-private collaboration. The SRP provides a mechanism through which up-front investment needed for companies, suppliers, and farmers to switch to climate-smart production methods can be made. The absence of a financial infrastructure to service millions of rice smallholders who lack access to services, the lack of public financing for governments to attract private sector investment through blended finance instruments, and the lack of credibility to leverage international climate finance to attract private sector investment for climate-smart rice production are the key issues which can be addressed using sustainable production models such as the SRP.
17. **Through the SRP, sustainable sourcing contracts for climate-smart rice are forged involving the key players in the rice value chain.** Better coordination is fostered between millers and processors who act as a key point of aggregation for farm produce and warehouse receipt operators who enable farmers to deliver their produce to a warehouse where they are presented with a receipt that can be used as collateral for obtaining credit from banks or MFIs. This in turn provides farmers with a viable form of collateral and mitigates the risks involved in lending to them and allows them to access loans at lower interest rates. In India, where this form of financing is quite widespread, interest rates for loans where warehouse receipts are used as collateral are 1.5–2 percent lower than the usual rate for farmers. Through the SRP, contracting mechanisms to buy sustainable rice from farmer cooperatives to ensure quality and traceability and developing brand value from sustainable rice linked to a lower environmental footprint and fairer trade to position sustainable rice in local, regional, and global markets are made possible through appropriate offtake agreements. A series of contractual arrangements along the value chain can help lower risks and increase access to capital. For example, offtake agreements—by which a company makes a promise to buy a certain volume of a crop at a fixed price at a certain date in the future—are a useful risk mitigation tool in smallholder farming. This can create three-way relationships between farmers, processors, and banks where banks provide credit to farmers, farmers sell their produce on a forward contract to processors, and processors then repay the loan to the banks.
18. **Through facilitating the types of offtake arrangements, the SRP is able to address barriers to financing, which is the key constraint in building a business model for climate-smart rice.** There are many examples of such arrangements. For example, Mars Food through its brand UNCLE BEN’S, the world’s largest rice brand, has been planning to source from farmers who are working toward the SRP standard by 2020—a first in the global rice industry. Mars Food is investing to raise living incomes of rice farmers and

implement water stewardship programs. It covers nine countries with 15 partner organizations such as IFC, GIZ, and Oxfam across Asia, Europe, and the United States. In Pakistan and India, Mars Food works with 2,000 basmati rice farmers to help them adopt sustainable practices. It has seen a 17 percent increase in yield, a 30 percent increase in farmer income, and a 30 percent reduction in water use from farmers adopting more sustainable growing methods.

19. **The SRP also enables a lot of digital financing arrangements—facilitating smooth payments to producers.** For instance, building on the work of various SRP partners in a focus country offers a focal point to develop and pilot a digital finance platform that integrates value chains and projects. For example, in Thailand, 5,000–10,000 smallholder farmers participate in sustainable rice production at different sites, with a plan to scale to 150,000 farmers in the next five years. This provides a basis for a technology or digital payments company committed to sustainable agriculture, such as Mastercard, to partner with the SRP and member companies on a Thai platform pilot. A partnership between the SRP, its members, and a company like Mastercard would allow the creation of a series of finance sector partnerships to deliver bundled financial services for smallholders, ranging from local banks to insurance companies. The Thai government has approved a US\$682 million national rice insurance scheme for over 4 million farmers launched by the Thai General Insurance Association and reinsurer SwissRe. It is part of a series of services that could be bundled together to benefit SRP-implementing smallholders. A digital finance platform would also enable faster, cheaper, and more transparent payout of crop insurance to smallholders, for example, by integrating the satellite monitoring technology used by SwissRe to create a faster trigger of crop insurance payments based on extreme weather events. Such arrangements and financing innovations would be possible in Vietnam. However, in Vietnam, currently only 8 percent of the farmers have been able to meet the standard to participate in the SRP. There is considerable opportunity to scale up the SRP as a business model to promote climate-smart rice production.



APPENDIX 3

ANALYTICAL APPROACHES AND A BRIEF DESCRIPTION OF THE COMPUTABLE GENERAL EQUILIBRIUM MODEL

METHODOLOGY: DATA AND ANALYSIS APPROACHES

1. **Most of the analysis in the report is based on official national-level datasets (VHLSS and AgroCensus) and global-level databases (WDI, FAOSTAT, and Agricultural Market Information System [AMIS]).** Also, the team undertook limited stakeholder surveys/deep-dive studies. The analysis approaches included estimates of agricultural land (tons per ha) and labor productivity (agricultural Value added per worker) as illustrated below. The team also employed agricultural public expenditure analysis and some limited benefit/cost analysis.

2. **Value added per household (VA_{hi}) is calculated as in equation 1,** where Q_{hi} is household h total output of commodity i and P_i is the output price per unit of commodity i , while M_{hi} and C_i are, respectively, the quantity of intermediate inputs used by household h of the total output of commodity i and the unit cost for the intermediate input i .

$$VA_{hi} = \sum_{k=0}^n Q_{hi} P_i - M_{hi} C_i \quad (1)$$

3. **Agricultural labor productivity (ALP_h) for a household h is estimated using equation 2,** where AL_h is the total agricultural labor in person days or hours spent on the farm.

$$VA_{hi} = \sum_{k=0}^n \frac{Q_{hi} P_i - M_{hi} C_i}{AL_h} \quad (2)$$

4. **Agricultural land productivity ($ALnP$) is estimated by equation 3,** where HAI is the amount of land under cultivation for a specific commodity i .

$$ALnP = \sum_{k=0}^n \frac{Q_i P_i - M_i C_i}{HAI} \quad (3)$$

5. **The results are presented in averages aggregated from the farm to the provincial and regional level.** The data are obtained from the VHLSS supplemented by AgCensus collected by the GSO in 2018.

A BRIEF DESCRIPTION OF THE CGE MODEL

6. **The World Bank's Mitigation, Adaptation, and New Technologies Applied General Equilibrium (MANAGE) model is used for the analysis.** MANAGE is a (recursive) dynamic single CGE model designed to focus initially on energy emissions and climate change. However, it has been modified for the analysis of agricultural and rice emissions. In addition to the standard features of a single country CGE model, the MANAGE model includes a detailed specification of the agricultural sector that allows for factor substitution in production, across all demand agents, and a multi-output multi-input production structure.
7. **The MANAGE model relies on behavioral assumptions that determine how economic agents react to various changes in the economy (for example, prices, income, and taxes) under well-defined constraints based on availability of resources.** The economic agents in MANAGE are households, production activities, government, and the rest of the world. Households are further disaggregated based on their socioeconomic status and labor based on the skill level, while production activities cover all sectors.

Furthermore, agricultural activities are disaggregated into various commodity-specific subsectors, including rice.

8. **The model was calibrated by using the 2018 SAM.** The macro aggregates (for example, GDP, trade, and consumption) were updated over time, allowing for a detailed analysis of agricultural, and in particular rice, supply and demand by incorporating different commodities and activities and the associated GHG emissions.
9. **Such assumptions generally make CGE models more suitable for long-term analysis.** Such models do not incorporate short-term adjustment costs such as price inflation or labor market frictions due to the time required for economic agents to adjust to new market signals. CGE models assume that agents would adjust almost immediately without facing any frictions in price formation for goods or factors of production such as labor or capital even if some sensitivity analysis about the degree of flexibility of the labor market is carried out.

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