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IMPLEMENTATION COMPLETION AND RESULTS REPORT

Credit No. 5704-VN

ON A

CREDIT

IN THE AMOUNT OF SDR 171.2 MILLION
(US$238 MILLION EQUIVALENT)

TO THE

SOCIALIST REPUBLIC OF VIETNAM

FOR THE

Sustainable Agriculture Transformation Project
May 8, 2023

Agriculture and Food Global Practice
East Asia and Pacific Region

CURRENCY EQUIVALENTS

Exchange Rate Effective June 30, 2022

Currency Unit =	Vietnamese Dong (VND)
VND 23,265=	US$1
US$1.33=	SDR 1

FISCAL YEAR
July 1 – June 30

ABBREVIATIONS AND ACRONYMS

1M5R	One Must Do, Five Reductions
3R3G	Three Reductions, Three Gains
ACP	Agriculture Competitiveness Project
ARP	Agricultural Restructuring Plan
AWD	Alternate Wetting and Drying
BIDV	Bank for Investment and Development of Vietnam
CPF	Country Partnership Framework
CPMU	Central Project Management Unit
CPS	Country Partnership Strategy
CSA	Climate Smart Agriculture
DARD	Department of Agriculture and Rural Development
ECOP	Environmental Code of Practice
EFA	Economic and Financial Analysis
EIRR	Economic Internal Rate of Return
FFS	Farmer Field School
FIRR	Financial Internal Rate of Return
FO	Farmer Organization
GAP	Good Agricultural Practice
GHG	Greenhouse Gas
GWP	Global Warming Potential
IAE	Institute for Agricultural Environment
ICR	Implementation Completion and Results Report
IFC	International Finance Corporation
IOT	Internet of Things
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
ISR	Implementation Status and Results Report
M&E	Monitoring and Evaluation
MARD	Ministry of Agriculture and Rural Development

MKD	Mekong Delta
MOF	Ministry of Finance
MTEF	Medium-Term Expenditure Framework
MTR	Midterm Review
NPV	Net Present Value
ODA	Overseas Development Assistance
PAD	Project Appraisal Document
PDO	Project Development Objective
PFI	Participating Financial Institution
POM	Project Operational Manual
PPC	Provincial People's Committee
PPMU	Provincial Project Management Unit
PPP	Public-Private Partnership
ToC	Theory of Change
TTL	Task Team Leader
VietGAP	Vietnamese Good Agricultural Practices
VnSAT	Vietnam Sustainable Agriculture Transformation Project

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DATA SHEET

BASIC INFORMATION

Product Information

Project ID	Project Name
P145055	Sustainable Agriculture Transformation Project
Country	**Financing Instrument**
Vietnam	Investment Project Financing
Original EA Category	**Revised EA Category**
Partial Assessment (B)	Partial Assessment (B)

Organizations

Borrower	Implementing Agency
SOCIALIST REPUBLIC OF VIETNAM	Ministry of Agriculture and Rural Development

Project Development Objective (PDO)

Original PDO

The project development objective is to improve farming practices and value chains in the targeted project areas, and promote institutional strengthening of relevant public agencies in effective support to implementation of the Agricultural Restructuring Plan.

FINANCING

	Original Amount (US$)	Revised Amount (US$)	Actual Disbursed (US$)
World Bank Financing			
IDA-57040	238,000,000	222,600,002	211,749,050
Total	**238,000,000**	**222,600,002**	**211,749,050**
Non-World Bank Financing			
Borrower/Recipient	12,000,000	27,685,000	29,283,000
Local Sources of Borrowing Country	64,000,000	135,701,000	135,701,000
Total	**76,000,000**	**163,386,000**	**164,984,000**
Total Project Cost	**314,000,000**	**385,986,002**	**376,733,050**

KEY DATES

Approval	Effectiveness	MTR Review	Original Closing	Actual Closing
30-Jun-2015	03-Dec-2015	03-Dec-2018	31-Dec-2020	30-Jun-2022

RESTRUCTURING AND/OR ADDITIONAL FINANCING

Date(s)	Amount Disbursed (US$M)	Key Revisions
21-Dec-2020	163.02	Change in Loan Closing Date(s) Cancellation of Financing Reallocation between Disbursement Categories Change in Disbursements Arrangements Change in Implementation Schedule
04-Jan-2021	163.18	

KEY RATINGS

Outcome	Bank Performance	M&E Quality
Highly Satisfactory	Satisfactory	Substantial

RATINGS OF PROJECT PERFORMANCE IN ISRs

No.	Date ISR Archived	DO Rating	IP Rating	Actual Disbursements (US$M)
01	30-Dec-2015	Satisfactory	Satisfactory	0
02	20-Jun-2016	Moderately Satisfactory	Moderately Satisfactory	11.38
03	18-Dec-2016	Moderately Satisfactory	Moderately Satisfactory	12.84
04	24-Jan-2017	Moderately Satisfactory	Moderately Satisfactory	13.06
05	29-Jun-2017	Moderately Satisfactory	Moderately Unsatisfactory	22.30
06	21-Dec-2017	Moderately Satisfactory	Moderately Satisfactory	39.86
07	20-Jun-2018	Moderately Satisfactory	Moderately Satisfactory	61.02
08	10-Jan-2019	Moderately Satisfactory	Moderately Satisfactory	94.34
09	16-Jul-2019	Moderately Satisfactory	Moderately Satisfactory	96.66
10	29-Jan-2020	Moderately Satisfactory	Satisfactory	121.93
11	18-Aug-2020	Satisfactory	Satisfactory	133.91
12	23-Jan-2021	Satisfactory	Satisfactory	163.68
13	02-Aug-2021	Satisfactory	Satisfactory	166.94
14	01-Mar-2022	Satisfactory	Satisfactory	192.00
15	29-Jun-2022	Satisfactory	Satisfactory	203.61

SECTORS AND THEMES

Sectors

Major Sector/Sector	(%)
Agriculture, Fishing and Forestry	**80**
Crops	51
Public Administration - Agriculture, Fishing & Forestry	8
Other Agriculture, Fishing and Forestry	21

Industry, Trade and Services	**20**
Agricultural markets, commercialization and agri-business	20

Themes

Major Theme/ Theme (Level 2)/ Theme (Level 3)	(%)
Economic Policy	**10**
Trade	10
Trade Facilitation	10
Private Sector Development	**20**
Business Enabling Environment	20
Investment and Business Climate	20
Urban and Rural Development	**70**
Rural Development	70
Rural Markets	50
Rural Non-farm Income Generation	20

ADM STAFF

Role	At Approval	At ICR
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I. PROJECT CONTEXT AND DEVELOPMENT OBJECTIVES

A. CONTEXT AT APPRAISAL

Context

1. **At the time of appraisal of the Vietnam Agriculture Transformation Project (VnSAT) in 2015, the Vietnam economy was slowing down following two decades of remarkable progress in economic growth and poverty reduction.** The slowdown was primarily due to international economic shocks compounded by domestic imbalances (nonperforming loans by poorly performing state-owned enterprises, the bursting of a real estate bubble, and so on). Before 2015, a variety of transformative changes occurred in the country. The gross domestic product grew at an annual rate of 7.5 percent during 1992–2007 and 5.8 percent during 2008–2014. Between 1993 and 2012, the extreme poverty rate fell from 64 percent to below 3 percent using the US$1.25 per day line. Vietnam had quickly transitioned from a substantially agrarian society to a more diversified 'modern industrial economy' and attained middle-income-country status in 2010. The share of the population with access to electricity increased from 40 percent to a remarkable 97 percent, an increasingly sophisticated export-oriented manufacturing sector emerged, Vietnam's urban centers grew significantly, and the country transitioned from being a net importer of food to being one of the developing world's largest and most diversified exporters of food and other agricultural products. It was the world's second largest exporter of rice and coffee. Despite the rapid structural changes, rural areas still provided the home and major sources of livelihood for approximately two-thirds of Vietnam's population and more than 90 percent of its poor.

2. **While Vietnam's agricultural sector had made enormous progress, there were concerns related to the quality and sustainability of the sector's growth and its patterns of development.** In particular, the Government was concerned about the modest incomes of many smallholder farm families, low or inconsistent performance on product quality and food safety, significant post-harvest losses, low value addition within the sector, and a slowing pace of productivity improvements. It was also becoming increasingly evident that parts of the country's agricultural growth were coming at the expense of the environment in the forms of deforestation, biodiversity loss, land degradation, water pollution, and increased greenhouse gas (GHG) emissions. Market failures or institutional shortcomings contributed to efficiency losses, while the sector's environmental costs were neither being internalized by producers nor reflected in the 'low cost' of Vietnam's commodity exports.

3. **The Government recognized an increasingly urgent need to promote a new agricultural development model.** In June 2013, the Prime Minister approved the Agricultural Restructuring Plan (ARP) of the Ministry of Agriculture and Rural Development (MARD). The ARP called for a shift in sectoral goals beyond physical (output or trade) targets to include a broader set of indicators related to the 'triple bottom line' of sustainable development. It laid out a set of core principles to guide the sector's development, the most significant of which were that (a) agriculture would need to be market-led and consumer-driven rather than state-directed and production-led and (b) the Government's role would need to shift from being the primary investor/service provider to being the facilitator of investments and services provided by the private sector, community organizations, research institutions, commercial banks, and others. The roles, approaches, and expenditures of the state in the sector would need to be 'restructured' to help realize the goals for sustainable agricultural development and rural transformation.

4. **Unsustainable growth trajectories and the need for a reorientation in the role of the state moving forward became apparent in two of the largest subsectors, rice and coffee.**[1] Much of the growth and dynamism in these subsectors had occurred in Vietnam's Mekong Delta (MKD) and the Central Highlands regions. The MKD region had grown to account for 55 percent of national rice production and 90 percent of its rice exports. However, productivity and export gains were no longer translating into improved living standards for most of the MKD's 1.4 million rice-growing households due to their very small farm sizes, excessive input use, and a fragmented value chain that yielded unnecessary logistical and handling costs and did not reward farmers for product quality. Exporting low quality rice was not generating wealth, least of all for the smallholder suppliers. Production practices were resulting in substantial environmental costs, including localized land and water pollution and emissions of GHGs. Rice exports largely targeted the lower-quality (that is, lower price) market segment, and the expectation was that higher-quality and specialty rice markets could be accessed by organizing farmers and linking farmer organizations (FOs) with milling and trading companies. Similarly, in the Central Highlands, the coffee subsector's product quality was low or variable, and the expansion and intensification of production had come at considerable environmental costs, including soil erosion and land degradation. In some areas, the excessive use of groundwater for irrigation contributed to the depletion of aquifers. About one-third of the existing coffee areas involved very old trees whose yields were declining. It was estimated that around 140,000–160,000 ha would need to be rejuvenated in the next 5–10 years. Overall, there were few examples of effective collective action amongst coffee farmers and relatively weak and/or irregular links between farmers and downstream processors and exporters.

5. **The VnSAT project supported Vietnam in implementing its ARP and was consistent with the World Bank Group (WBG) Country Partnership Strategy (CPS) for 2012 – 2016.**[2] It contributed to the 'competitiveness' and 'sustainability' pillars through increased capacity for innovation and value addition in (agricultural) value chains (outcome 1.3), improved natural resource management, including water resource management (outcome 2.1), and strengthened environmental protection and management (outcome 2.2). The project addressed key governance challenges including improving supply chain governance and piloting landscape approaches to improve natural resource management and sustainable development. In addition, the project addressed the Government's priorities concerning building climate resilience in rice and coffee farming systems, improving supportive infrastructure and the enabling environment, and addressing issues related to product quality, value addition, and reduction of post-harvest losses. VnSAT would help to operationalize key elements of the ARP in the context of the large and strategic sub-sectors of rice and coffee which, despite the increasing diversification of Vietnam's agricultural sector, still accounted for 40 percent of agricultural employment in the early 2010s.

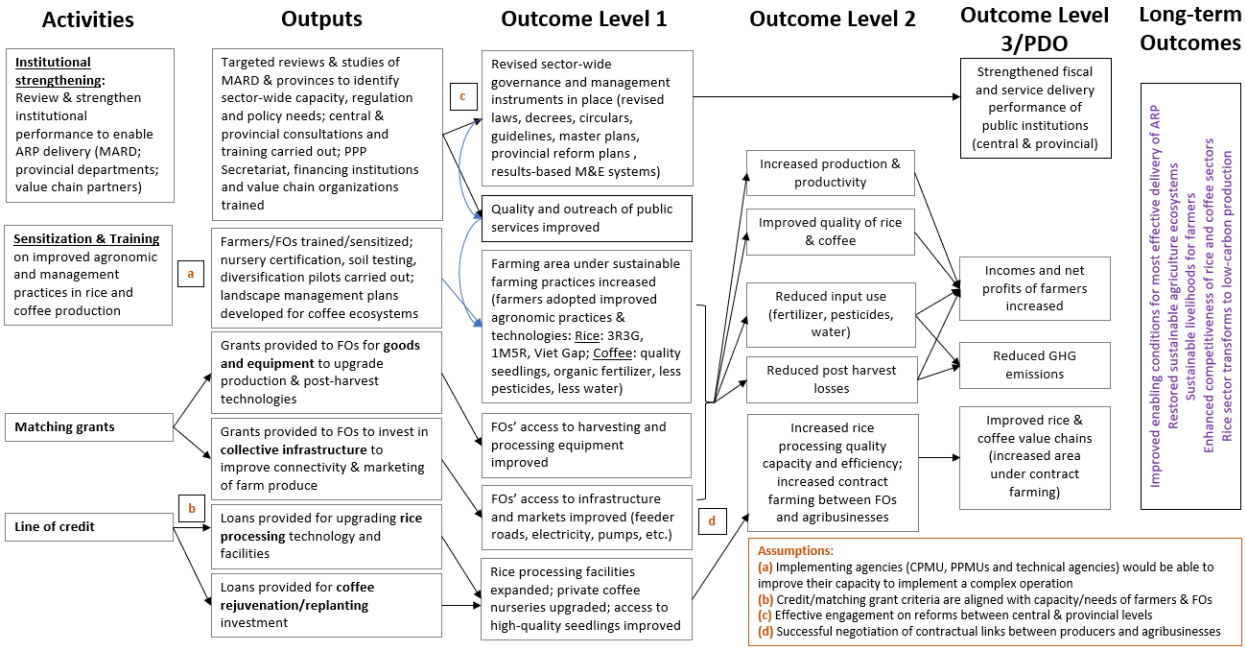
Theory of Change (Results Chain)

6. The Project Appraisal Document (PAD) did not include the Theory of Change (ToC) as it was not required at appraisal. For this review, the ToC depicted in figure 1 was derived from the PAD project description. The inferred ToC of the VnSAT posits that the key objectives[3] under the national ARP can be achieved by focusing investments under the project on: (a) strengthening the fiscal and service delivery

[1] At the time, Vietnam was the world's second largest producer of rice and coffee.
[2] World Bank Country Partnership Strategy for the period FY12-FY16, Report No. 65200-VN.
[3] "(i) Agriculture will be market-led and consumer-driven rather than state-directed and production-led; and (ii) the government's role will shift from being the primary investor/service provider to being the facilitator of investments and services provided by the private sector, community organizations, research institutions, commercial banks and others."

performance of MARD and its respective agricultural departments at the provincial level to enable the most effective delivery of the ARP; (b) developing rice-based and coffee-based production systems through scaling up the adoption of improved farm-based production and management technologies and organizing farmer groups to access collective harvesting and primary processing equipment; and (c) providing access to credit to upgrade rice processing technologies and facilities and rejuvenating coffee plantations to promote the performance of the product value chain. The ToC also maps out how improved rice production technologies promoted by the project represent a low-carbon cultivation approach that significantly reduces GHG emissions and improves efficiency by reducing the intensity of input use while increasing productivity and profitability. In the long term, upscaled adoption of these technologies has the potential to transform Vietnam's rice production into an advanced low-carbon production system while also restoring the agro-ecology and sustaining people's livelihoods.

Figure 1. Inferred Theory of Change – VnSAT



Note: 1M5R = One Must Do, Five Reductions; 3R3G = Three Reductions, Three Gains; M&E = Monitoring and evaluation; PPP = Public-private partnership; FOs = Farmer organizations

Project Development Objectives (PDOs)

7. The PDO is to improve farming practices and value chains in the targeted project areas and promote institutional strengthening of relevant public agencies to effectively support implementation of the Agricultural Restructuring Plan.

Key Expected Outcomes and Outcome Indicators

8. The PDO-level result indicators were the following:

- **Improved farming practices (in rice and coffee) production in targeted provinces**
  - Indicator 2: Farming area under sustainable farming practices (a) Rice production (ha); (b) Coffee production both existing plantations and rejuvenation (ha)
  - Indicator 4: Reductions in GHG emissions from rice farming in the project area (tons)
- **Improved rice and coffee value chains**
  - Indicator 3: Increase in net profits per hectare among targeted farmers in (a) Rice production (percentage); (b) Coffee production (percentage). It must be noted that Indicator 2: Farming area under sustainable practices was also expected to contribute to the achievement of this Indicator 3.
- **Strengthened public agencies to effectively support implementation of the Agricultural Restructuring Plan**
  - Indicator 5: Improved quality of service delivery by MARD and Departments of Agriculture and Rural Development (DARDs) in support of project implementation as measured by a performance scorecard for: (a) MARD; and (b) DARDs

9. In addition, the project design included an outreach indicator: PDO Indicator 1: Number of project beneficiaries (people).

Components

10. The project comprised the following four components: (A) Institutional Strengthening to Support Agricultural Transformation; (B) Supporting Sustainable Rice-Based Systems; (C) Supporting Sustainable Coffee Production and Rejuvenation; and (D) Project Management, Monitoring and Evaluation.

Component A: Institutional Strengthening to Support Agricultural Transformation (allocated: US$6.3 million, of which US$5.0 million IDA; actual: US$2.7 million, of which US$1.8 million of IDA and US$0.9 million from the Government)

11. **This component was designed to support three activities:**

- (A1) Capacity development for MARD to design, implement, and monitor agricultural growth and sustainability initiatives, including: (a) organizational development and capacity building for the effective implementation of ARP; (b) strengthening of human resource management in MARD departments; and (c) capacity strengthening for results-based planning, public expenditure management, and policy analysis.
- (A2) Capacity development for the provincial DARDs in selected pilot provinces focusing on the core services to be delivered to the end users and the implementation of thematic reforms led by MARD's Department of Planning under A1.
- (A3) Capacity development for value chain partners to enhance private sector involvement through the ARP, including institutional support for the establishment and management of the planned Public Private Partnership (PPP) secretariat, training of local financing institutions, and institutional strengthening of the value chain organizations in the rice and

coffee sectors (for example, Vietnam Coffee Coordination Board and Vietnam Food Association).

Component B: Supporting Sustainable Rice-Based Systems (allocated: US$182.6 million, of which US$140.4 million IDA; actual: US$176.92 million, of which US$96.43 million of IDA, US$13.69 million from the Government, and US$66.8 million from mobilized private sector financing)

12. **This component was designed to support approximately 30 key rice-producing districts in eight MKD provinces in a cluster approach.** It consisted of three activities:

- (B1) Support a large-scale program on improved agronomic practices and management: to do this, the project procured technical services of the International Rice Research Institute (IRRI) to support MARD and project provinces in designing and implementing the activities.
- (B2) Support private sector investments in upgrading rice processing technology and facilities for high-value and quality rice through the provision of loans (4–7 years) via commercial banks.
- (B3) Improve public services delivery particularly extension services, foundation seed production, and seed certification.

Component C: Supporting Sustainable Coffee Production and Rejuvenation (allocated: US$98.7 million, of which US$83.0 million IDA; actual: US$184.0 million, of which US$107.2 million of IDA, US$7.9 million from Government and US$68.9 million from mobilized private sector financing)

13. **This component was designed to transform parts of Vietnam's coffee sector to adopt sustainable production practices.** The component was designed along three streams of activities:

- (C1) Promotion of improved farm agronomic and management practices via farmer field school (FFS) training and matching grants to adopt water-saving technologies and other improved agricultural practices.
- (C2) Support for sustainable coffee rejuvenation/replanting through: (a) provision of long-term loans via a line of credit administered by the Bank for Investment and Development of Vietnam (BIDV) and disbursed through participating financial institutions (PFIs) to cost-share coffee replanting investments and (b) strengthening of private nurseries to meet the demand of rejuvenating farmers for quality seedlings and buds.
- (C3) Improve public services delivery by: (a) strengthening participatory planning and assessment processes for coffee rejuvenation; (b) conducting pilots (one pilot per province) at the community or district levels to draw experience and lessons of integrated landscape management approach in coffee-based ecosystems; and (c) upgrading critical public supporting services, including nursery certification, soil testing, diversification pilots, awareness raising, and communications.

Component D: Project Management, Monitoring and Evaluation (allocated: US$13.4 million, of which US$9.6 million IDA; actual: US$12.7 million, of which US$6.0 million of IDA, US$6.7 million from the Government)

14. This component supported (D1) project management and (D2) monitoring and evaluation.

B. SIGNIFICANT CHANGES DURING IMPLEMENTATION

Revised PDOs and Outcome Targets

15. No change.

Revised PDO Indicators

16. No change.

Revised Components

17. No change.

Other Changes

18. **The project underwent one Level 2 restructuring on November 19, 2020,** to (a) extend the project's closing date from December 31, 2020, to June 30, 2022, and (b) cancel US$15.4 million of the IDA Credit. The amount cancelled was initially earmarked for establishing a Cooperative Fund to on-lend to rice and coffee cooperatives supported by the project.

Rationale for Changes and Their Implication on the Original Theory of Change

19. The rationale for project restructuring included the following:

(a) To help ensure better sustainability of the project outcomes, a project extension was needed due to the late allocation of the budget for 2019 and previous years, which contributed to considerable delays in implementing all infrastructure subprojects along with completing the capacity development activities of farmers.

(b) The Banking Law did not allow group lending; therefore, the initiative of establishing a Cooperative Fund for on-lending to FOs and cooperatives was not possible.[4] This resulted in a cancellation of US$15.4 million of the IDA Credit, which was initially earmarked for establishing a Cooperative Fund to on-lend to rice and coffee cooperatives supported by the project. This cancellation did not affect the achievement of the PDO as commercial banks

[4] During project implementation, the establishment of Cooperative Fund to on-lend to FOs and cooperatives did not receive support from the MOF as it was not consistent with the revised Banking Law, which did not allow group lending. As a result, according to the MOF's opinion in Official Letter No. 8897/BTC-QLN, dated August 5, 2019, MARD proposed to cancel this part of the IDA credit (Source: VnSAT PCR Report).

followed existing procedures and channels to lend to individual farmers targeted by the project.

20. These changes did not affect the ToC or the project scope, objectives, and outcomes.

II. OUTCOME

A. RELEVANCE OF PDOs

21. **The relevance of the VnSAT PDO was high at appraisal and remained high at project closing.** While Vietnam had achieved remarkable growth in agricultural exports and ranked among the top global exporters of rice and coffee at the time the project was appraised, there were concerns related to the quality and sustainability of agricultural growth and related patterns of development. Challenges included low smallholder farmer profitability, mixed or uncertain product quality and food safety, low value addition, significant post-harvest losses, and limited technological or institutional innovations. The consequences of the over-intensive input and natural resource use for growing rice and coffee—both for the environment and farmer profitability—were increasingly recognized. Market failures and institutional shortcomings contributed to the efficiency losses. Vietnam's agriculture needed to generate more economic value and improve farmer and consumer welfare through more efficient use of natural, human, and other resources. It required structural changes in the pattern of production and supply chain organization to deal with institutional weaknesses and regulatory barriers pertaining to cooperative/enterprise development and investments in the sector. Change was also needed in the model of state management of the sector. A stronger and more sophisticated market orientation required a change in the quality of technical and regulatory services provided by the state, in the composition of public investments and expenditures in the sector, and in policies to foster farmer and agribusiness investments. These changes called for a long-term restructuring program that required one or more decades to complete, and the VnSAT was the first step to establish the foundation for the long journey.

22. The fundamental premise of the VnSAT was to support the implementation of the Government's ARP strategic pillar, which focused on 'generating more from less' by achieving more economic value—and farmer and consumer welfare—using less natural and human capital and less harmful intermediate inputs. To this end, the project was designed to strengthen various institutional capacities related to the restructuring and sustainability agendas, with a focus on interventions in two regions and two priority crop sectors, rice and coffee, to show demonstrable long-term transformative impacts. It remains relevant and also helped inform the new MARD Sustainable Agriculture and Rural Development Strategy for the 2021–2030 period with the Vision to 2050 approved in January 2022, which gives priority to promoting efficient, environmentally sustainable, climate-resilient, and low-carbon agriculture. The VnSAT low-carbon rice experience has also informed the design of MARD's national 1 million-hectare high-quality and low-carbon rice program. The project remained highly relevant at closing by contributing to two of the three Focus Areas of the Vietnam Country Partnership Framework (CPF) for FY18–22, namely: (i) enabling inclusive growth and private sector participation; and (ii) ensuring environmental sustainability and resilience, with governance as a cross-cutting engagement area.[5] Specifically, the project responded

[5] Vietnam - Country partnership framework for the period FY18-FY22 (English). Washington, D.C. : World Bank Group (Report No. 111771-VN). A new Country Partnership Framework for the period FY23-27 is under preparation.

to Objectives 1 and 2 under Focus Area 1, (a) strengthening economic governance and market institutions and (b) promoting private sector and agri-business development. Further, the project supported Objectives 10 and 11 under Focus Area 3, (a) increasing climate resilience and strengthening disaster risk management and (b) strengthening natural resource management and improving water security.

Assessment of Relevance of PDOs and Rating

23. With clear evidence of the high degree of alignment of the PDO with Government strategies and the current World Bank CPF as described above, the relevance of the PDO is rated 'High'.

B. ACHIEVEMENT OF PDOs (EFFICACY)

Assessment of Achievement of Each Objective/Outcome

24. **At the time of preparation of this Implementation Completion and Results Report (ICR), the VnSAT has already been widely acknowledged as a best practice 'green' agricultural transformation project.** The project has offered climate-smart agriculture (CSA) solutions to grow rice and coffee in an environmentally sustainable way that can increase productivity, improve climate resilience, reduce GHGs, and, most importantly, increase farmers' incomes. The project's encouraging results of moving to low-carbon rice, in particular, have shown that these CSA practices can be further scaled up in Vietnam and replicated in other countries. The VnSAT achievements have been acknowledged by the Government of Vietnam and broadcasted via its mass media channels (see annex 7) as well as documented in various academic/analytical studies including those prepared by the staff of the World Bank.

25. **The project fully achieved its development objectives of (a) improving farming practices, (b) improving value chains in the targeted project areas, and (c) promoting institutional strengthening of relevant public agencies to effectively support implementation of the ARP.** The efficacy was assessed based on the level of achievement of the PDO and intermediate indicators as per the project's Results Framework. The analysis was drawn from the borrower's Project Completion Report, the borrower's Final Report on the Completion of Component A, BIDV's Final Comprehensive Report on the Project Credit Line, project Aide Memoires, project progress reports, and mission findings of the ICR team. The efficacy assessment was also supplemented with relevant data and evidence from the analytical and research papers featuring the VnSAT. All data sources and references are listed in annex 6.

PDO Part 1: Improved farming practices in rice and coffee production in the targeted provinces

26. **The project's performance on the achievement of Part 1 of the PDO is rated *High*.** The relevant PDO and intermediate indicators established under the Results Framework were overachieved, as summarized in table 1.

Table 1. PDO 1: Improved Farming Practices in the Targeted Project Areas

	Baseline	Target	Actual	Achievement (%)
PDO Part 1 Indicator				
Farming area under sustainable farming practices (a) Rice production (ha)[a]	0	150,000	184,643	123

(b) Coffee production both existing plantations and rejuvenation (ha)	0	50,000	70,446	141
Reductions in GHG emissions from rice farming in the project area (tons)	0	1,000,000	1,582,299	158
Intermediate Results Indicator				
B1. Area of rice farming under sustainable farming practices as measured by reductions in pesticide and fertilizer use (ha)	0	150,000	208,951	139
C1. Coffee area adopting sustainable farming practices as measured by reductions in pesticide and fertilizer use (ha)				
(a) Existing plantations	0	40,000	53,200	133
(b) Rejuvenation	0	10,000	18,283	182[b]
C2. Coffee area adopting advanced water-saving irrigation technologies and reducing water use by at least 20 % in the project areas (ha)	0	22,000	57,868	263[b]
C3. Area replanted with certified planting materials in the project areas (ha)	0	7,000	22,721	325[b]

Note: a. 3R3G practice (that is, less than 100 kg seeds per ha, less than 120 kg nitrogen per ha, less than 5 pesticide applications for winter crop/less than 3 applications for autumn crop).
b. The achievement rates for coffee-related targets are significantly higher than initially targeted due to an increase in funding under the credit line for coffee rejuvenation from US$50 million to US$71.73 million. In March 2020, the On-Lending Loan Agreement between the Ministry of Finance (MOF) and the BIDV was amended to merge the credit line allocation for rice (US$55 million) with the credit line allocation for coffee (US$50 million) to meet the increased market demand for the coffee credit line. This change did not require a formal project restructuring with the World Bank. The IDA credit line for rice agribusinesses was reduced, and it was topped up by additional funds from commercial banks' own resources.

Scaling Up the Use of More Sustainable Rice Production Technologies: 3R3G and 1M5R

27. The project helped promote and scale up technologies already introduced in Vietnam during the early 2000s and that had become nationally approved best practices for irrigated agriculture. Farmers in the MKD typically cultivated less than 1 ha for rice production, and they were overusing chemical fertilizers and pesticides, which has detrimental effects on water quality, biodiversity, and human health. The immediate objective of promoting the use of new technologies was to overcome farmers' knowledge gaps that had translated into poor and inefficient management of resources, resulting in reduced profits, increased health risks, and environmental pollution. A national program supported by the project promoted nationally approved best management practices through two technology packages: 'Three reductions, three gains (3R3G)' and 'One Must Do, Five Reductions (1M5R)' (see box 1). Under VnSAT, the dissemination of these rice production technologies was scaled up in the MKD.

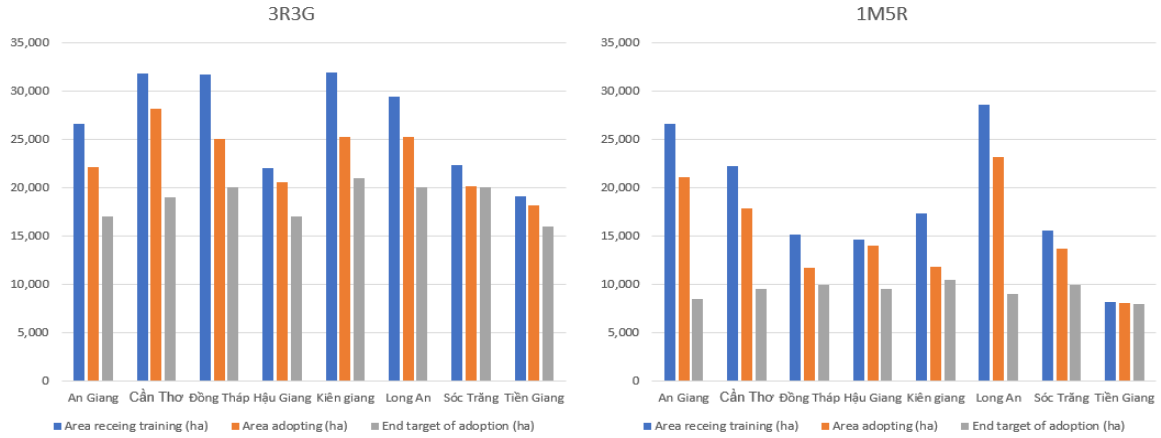
Box 1. Rice Production and Management Practices Promoted by the Project

Three reductions, three gains (3R3G). 3R3G evolved from the promotion of 'integrated pest management' practices and aims to reduce input requirements without sacrificing yield. The three reductions encompass a reduction of seed rate, fertilizer use, and insecticide spraying. The three gains are an increase in yield, quality of farm produce, and net farm profit.

One Must Do, Five Reductions (1M5R). 1M5R is also an integrated technology package that aims to promote best management practices in lowland rice cultivation. It was developed using the requirements specified in the 3R3G practice, whereby the package promotes the use of certified seeds, which is the 'One Must Do' combined with five reductions, which encompass the reduction of seed rate, fertilizer use, pesticide use, water use, and post-harvest losses.

28. The use of improved farming practices in rice production reduced over-reliance on agrochemicals and reversed farmers' attitude of 'more (inputs) is better'. Through technical training courses, demonstration models, and FFSs, the project trained 156,536 farmers cultivating an area of 214,706 ha using the 3R3G approach. Out of these households that had embraced the 3R3G approach, 105,759 households cultivating 148,431 ha were further trained on the advanced '1M5R' technology package. 3R3G and 1M5R overlapped in reducing the seeding rate and fertilizer and pesticide use, but compared to 3R3G, the 1M5R technology moved further to the use of certified seeds, the practice of alternate wetting and drying (AWD) to reduce flooding time and water pumping, and the use of combine harvester technology to minimize post-harvest losses. By the project closing, the areas adopting the 3R3G and 1M5R were 184,463 ha and 121,508 ha, respectively.

Figure 2. Rice Training and Adoption by Provinces



Source: CPMU's Report by June 2022.

29. An adult learning strategy was successfully used to catalyze the opportunity of changing farmers' beliefs and attitudes and increasing their understanding of their farming system and social networks. Actors in the rice value chain were also targeted, such as farm laborers, harvesting service providers, millers, and rice traders, so that they supported the shift in the behavior of farmers.[6] By the project closing, the adoption rate of 3R3G[7] was estimated at 86.8 percent of all trained farm households and 83.5 percent for 1M5R. As a result, the area under sustainable farming practices reached 184,643 ha for 3R3G, of which 121,508 ha (or 66 percent) of this area further advanced to using 1M5R practice (see figure 2).

30. Evidence from independent studies suggests a lower, but still impressive, rate of adoption for most elements of the technology package. Connor et al. (2021)[8] undertook a study on the adoption of 1M5R by farmers in An Giang and Can Tho provinces, surveying 465 farmers. Most farmers followed the requirements of pesticide reduction (74.4 percent), fertilizer reduction (73.8 percent), post-harvest loss reduction (99.6 percent), and the use of certified seeds (90.5 percent). Farmers have also reduced their seeding rate (86 percent). Although farmers reduced their seeding rate by 77 kg per ha, which accounts for an estimated 30 percent decrease, they still used an average of 164 kg per ha, compared to the recommended <100 kg per ha. The majority of farmers used two to three of the recommended 1M5R technologies (78.9 percent), and the most-adopted technologies were combine harvesters (99.6 percent) followed by AWD (n = 161, 34.6 percent) and high-yielding varieties (n = 131, 28.2 percent).

31. In another study, Wehmeyer (2021)[9] conducted a comparative analysis using survey data collected in 2014 and 2019 and estimated the treatment effects by establishing a treatment and control group. The adoption rate was particularly high for the combine harvester (100 percent), drum seeder (95.4 percent), AWD (93.7 percent), and the use of improved varieties (88.8 percent). Considerable spillover effects occurred over the five-year period; control farmers also adopted the combine harvester (100 percent), drum seeder (75.8 percent), AWD (78.1 percent), and the use of improved varieties (92.2 percent). In general, farmers indicated that the benefits of adopting one or more 1M5R technologies were reduced labor (95.6 percent), lower input cost (79.3 percent), better yields (65.9 percent), and better crop stand (57.8 percent).

32. **Dissemination of supplementary techniques.** A small share (2.5–4 percent) of trained farm households received additional training on supplementary techniques, including crop rotation, utilization

[6] See Flor, R. J., L. A. Tuan, N. V. Hung, N. T. My Phung, M. Connor, A. M. Stuart, B. O. Sander, H. Wehmeyer, B. T. Cao, H. Tchale, et al. 2021. "Unpacking the Processes that Catalyzed the Adoption of Best Management Practices for Lowland Irrigated Rice in the Mekong Delta." *Agronomy* 11: 1707. https://doi.org/10.3390/agronomy11091707.

[7] Calculated using a method established in the project's M&E Manual, whereby, for 3R3G, data on seed volume, nitrogen volume, number of pesticide applications, and quality of recording in the 'Farm Production Recording Book' are collected seasonally from a sample of farmers and validated through interviews and joint field observation visits. Certain thresholds for adoption/non-adoption were established for each criterion (that is, less than 100 kg seeds per ha, less than 120 kg nitrogen per ha, less than five pesticides applications for winter crop/less than three applications for autumn crop, and good recording practice), only if all thresholds were met, a farmer was considered to be 'adopting'. The sample size was proportional to the number of registered areas of each province.

[8] Cited in Flor, R. J., L. A. Tuan, N. V. Hung, N. T. My Phung, M. Connor, A. M. Stuart, B. O. Sander, H. Wehmeyer, B. T. Cao, H. Tchale, et al. 2021. "Unpacking the Processes that Catalyzed the Adoption of Best Management Practices for Lowland Irrigated Rice in the Mekong Delta." *Agronomy* 11:1707. https://doi.org/10.3390/agronomy11091707.

[9] Wehmeyer, H. 2021. "Sustainable Rice Production in the Mekong River Delta: Factors Influencing Farmers' Adoption of the Integrated Technology Package "One Must Do, Five Reductions" (1M5R)". *Outlook Agric.* 50: 90–104.

of rice byproducts, multiplication of certified rice seed varieties, and VietGAP[10] rice production. This training program helped farmers earn additional income in addition to rice. For instance, rice cooperatives in Can Tho recycled rice straws to cultivate mushrooms, and they could produce around 150 kg of mushrooms per one ton of rice straws, generating a profit of VND10 million per 500m2 per 30-day crop. This additional income was significantly higher than the income from rice farming, around VND7-8 million per ha per 3-month crop.

33. **Constraints faced by non-adopting beneficiaries.** About 16 percent of beneficiary farmers had problems in adopting some of the techniques, including reducing water use (that is, applying AWD) and reducing seed rates. A study by Tuan et al. (2021) identified external factors such as the geographical location of the farm, land preparation, weather conditions, and access to machinery as the main barriers to adoption.[11]

34. **Drivers of adoption.** Tuan et al. (2021) find that rates of 3R3G/1M5R adoption are not driven by a few factors, such as farm characteristics (various levels of water access, pest exposure, land surface, and so on) or experiences (individual experience and experience with previous extension program). Adoption rates are driven by multiple characteristics including: (a) socioeconomic status (rich, better-off, average, poor, and near poor); (b) educational status of the beneficiary farmers; (c) size of plot; (d) adopter categories (innovators, early adopters, early majority, late majority, and laggards); and (e) interests, motivations, and needs.[12] The conclusion is that adoption can be promoted by continuing to provide demonstration fields and extension services and by investigating the organizational structure of farming cooperatives, their needs, and business model abilities to acquire and maintain machinery for the rice farming communities. This also suggests exploring a more differentiated approach to the recommended technology package based on the geographical and socioeconomic context of project farmers.

35. **GHG emission reduced.** Despite all its successes, agriculture 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.[13] Emissions result from the anaerobic decomposition of organic material in flooded rice fields that produce methane which escapes to the atmosphere primarily through air bubbles and by being transported through the rice plants. The amount emitted is a function of the rice species, the number and duration of harvests, the soil type and temperature, the irrigation method, and fertilizer use. The 1M5R package promotes the application of proper seed densities (by reducing the current seeding rates by 30–40 percent), which helps reduce the amount of inorganic nitrogen application accordingly. Applying AWD and irrigating at the right time of the growth of rice plants helps save considerable freshwater irrigation and flooded time for paddy. Reducing post-harvest losses and better recycling of rice straws helps reduce the amount of straw burning. These techniques together reduce overall GHG emissions. The VnSAT design set an ambitious target of reducing

[10] VietGAP (Vietnamese Good Agricultural Practices) is a certified standard on good agricultural practices (GAP) in Vietnam. It builds on the technological components and training of 1M5R, as well as the consolidation of farmers into cooperatives under the Large Rice Fields Model (LRF).
[11] Tuan, Le Anh, Helena Wehmeyer, and Melanie Connor. 2021. "One Must Do, Five Reductions" Qualitative Analysis of the Diffusion and Adoption Constraints in Vietnam." *Development in Practice.* DOI: 10.1080/09614524.2021.1937556.
[12] Tuan, L. A., and G. R. Singleton. "Promoting Adoption of Agricultural Technologies Three Reductions, Three Gains—One Must Do, Five Reductions Guidance Note." 2018. International Rice Research Institute: Los Baños, Philippines.
[13] World Bank. 2022. *Spearheading Vietnam's Green Agricultural Transformation: Moving to Low-Carbon Rice*.

GHG emissions by 1 million tons annually as a PDO indicator. It was visionary back in 2014–2015 and was one of the first agricultural operations in the region or the world to do so at that time. The reduction in GHG emissions from improved rice farming practices in the project area (with 184,643 ha of rice in the MKD) is estimated to be 1,582,299 tons per year, that is, 58 percent above the project target of 1 million tons.[14] This is because the area adopting improved rice farming practices by project closing was significantly higher than initially planned. A detailed description of the methodology for estimating the GHG reduction is provided in annex 8.

Scaling Up of Sustainable Farming Practices and Rejuvenation in Coffee Production

36. An aging tree stock, over-intensive production measures, and climate change have been threatening the productivity of coffee production in the Central Highlands of Vietnam. The project has trained 54,123 coffee farm households, with a total farming area of 70,446 ha in five provinces,[15] on the application of sustainable coffee production practices. The practices promoted included two main elements: (a) the use of less inputs (nitrogen and pesticides), increased use of organic fertilizer, application of water-saving technologies, and inter-cropping with shade (fruit) trees) and (b) the rejuvenation of coffee plantations with certified seedlings.

37. High adoption response put farmers on a positive development track. Results from regularly conducted adoption monitoring surveys (see paragraph 96) established that adoption rates of existing coffee plantations targeted by the project reached 84 percent and 82 percent for coffee rejuvenation. By the project closing, the areas of existing coffee plantations and coffee rejuvenation fully applied all project criteria for sustainable coffee production were 52,163 ha and 18,283 ha, respectively (figure 3). The adoption response was 30 percent higher than expected. Due to the high adoption rates, the farmers were able to increase both their yields and the quality of the coffee produced. This reduced total expenses for fertilizer; allowed them to sell their coffee at higher prices (due to the better quality of the harvested coffee beans); and, as a result, increased their incomes (see paragraph 48).

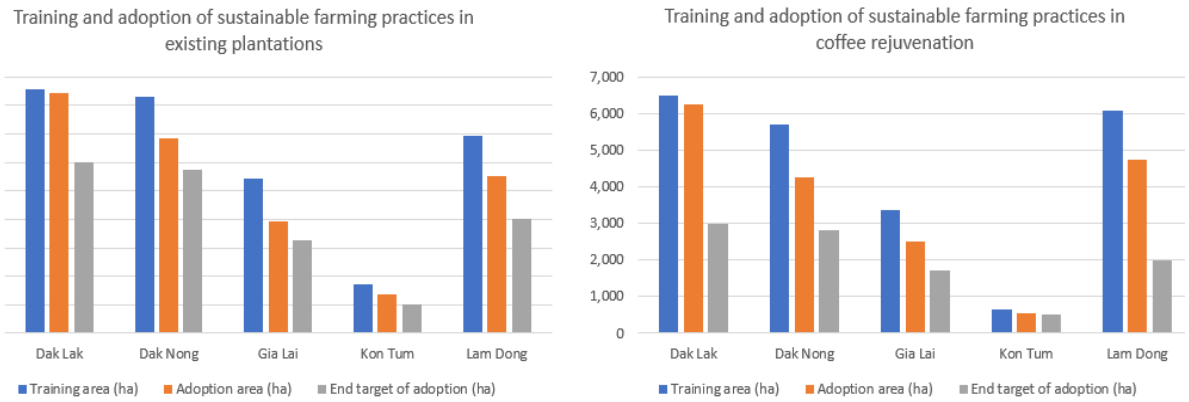
38. **Constraints faced by non-adopting beneficiaries.** Only those farmers who adopted the full technology package (see paragraph 36) were included in the count of adopters. Interviews with stakeholders revealed, however, that in some regions, there were evident and reasonable explanations for not adopting the full package as rigidly as advised—namely, local climate patterns and soil characteristics, farm income levels, education, and ethnicity. Due to local weather conditions, some production areas required either more or less supplementary irrigation of the coffee plants.[16] Likewise, the recommended organic fertilizer amount was considered too high by some farmers in high rainfall areas as they were concerned that the fertilizer applied would filter down too quickly and destroy roots, and therefore, some farmers did not apply the full recommended amount. Others felt that applying the full recommended amount of organic fertilizer in Year 1 was financially not feasible (that is, liquidity

[14] The $MTCO_2$ equivalent was calculated based on the number of farmers who adopted improved farming practices and the volume of GHG emissions reduction per ha. Two methods were applied: (a) direct measurement on field emissions (implemented by national consultancy firm) and (b) estimated to reduce emissions based on rice area adopted under 1M5R and 3G3R (Source: VnSAT M&E Manual).
[15] Dak Lak, Dak Nong, Gia Lai, Kon Tum, and Lam Dong provinces.
[16] For example, Lam Dong is relatively more humid than Dak Nong, which faced repeated droughts in some areas.

constraints). Finally, it has been challenging for extension services to fully engage with farmers of certain ethnic groups, which may also explain only partial adoption in certain areas.

39. **Heterogeneous net benefits to the technology determined adoption.** Based on the constraints described (above), the actual and, in some cases, the farmers' perceived benefits and cost of technologies have varied. This may explain the difference in adoption rates across participating provinces—ranging from about 70 percent of beneficiary farmers in Gia Lai to 98 percent in Dak Lak.[17]

Figure 3. Coffee Training and Adoption by Province



Source: CPMU's Report by June 2022.

40. **Supplementary training results.** The project also delivered specialized training to a subgroup of farmers as well as the staff of the public and private nurseries to further strengthen the production system. These included capacity development on: (a) the propagation of coffee plants, (b) coffee nursery certification, (c) disease surveillance and management, (d) soil analysis and nutritional diagnosis, (e) diversification of crop systems by intercropping techniques in coffee gardens, and (f) capacity building for FOs.

PDO Part 2: Improved rice and coffee value chains[18]

41. **The project's performance on the achievement of Part 2 of the PDO is rated *High*.** The project surpassed all targets set for the respective PDO level and intermediate indicators, as presented in table 2.

Table 2. PDO 2 and Intermediate Results Indicators: Baseline, Targets, and Actual Achievements

	Baseline	Target	Actual	Achievement (%)
PDO Part 2 Indicator				

[17] This observation is also described elsewhere in scientific literature (for example, Suri, Tavneet, Econometrica Vol. 79, No. 1 (January 2011), pp. 159–209 (51 pages).

[18] Data presented in this section are based on the borrower's Project Completion Report and BIDV's Final Comprehensive Report

	Baseline	Target	Actual	Achievement (%)
Increase in net profits per hectare among targeted farmers (a) Rice production (%) (b) Coffee production (%)	0 0	30 20	32 22.4	107 112
Intermediate Results				
B2. Area of sustainable rice farming applying improved farming and postharvest packages to reduce 30% water use and postharvest losses (ha)	0	75,000	135,247	180
B3 Area of sustainable rice farming under contract farming arrangements with agribusinesses (ha)	0	50,000	74,234	148
B4. Investments by project-supported agribusinesses in additional milling/ processing capacity (US$, million)	0	40	97.31[a]	243

Note: a. US$33.27 million was from the IDA credit; US$2.11 million was from the Revolving Fund and the remaining US$61.93 million was leveraged by PFIs and end-borrowers. These sources of funds were blended to lend agribusinesses to upgrade their milling and processing facilities.

Rice Value Chain Improvements

42. **Net profits increase.** Through the project support, the average profit per hectare of the targeted rice farmers increased by 30 percent compared to before the project[19] (when compared with the non-target group, the average profit increased by 32 percent). This result equates to 107 percent of the end target. This result was achieved through the following project interventions: (a) the establishment and consolidation of FOs, (b) the training of farmers and key officers, and (c) the support for equipment and production infrastructure for farmers in FOs**.** A key factor of success was that farmers properly applied the technical measures for which they received training and reduced production costs through the efficient use of inputs while maintaining or increasing production yield and quality.

43. **Capacity of FOs and cooperatives developed.** For the rice component, the project supported the establishment and consolidation of 308 FOs, including 265 cooperatives and 43 cooperation groups in 8 MKD provinces. Specifically, the project supported the establishment of 121 new FOs and the strengthening of 187 existing FOs. The cooperatives supported by the project also increased in size. The number of members joining the cooperative increased from 15–20 people when established to 100–200 people, with some even reaching 300 people. The FO area coverage ranges from 10 to 2,992 ha, with an average of 408 ha. As a result of the project's support, 151,000 farming households have properly applied sustainable rice cultivation practices covering a total area of 184,643 ha. Specific results of the application of sustainable rice production practices in the MKD have led to the following:[20]

- **Reduced seed volume use.** Following the project training, about 83 percent of the households have properly applied the criteria of reducing the seeding rate to below 100 kg of seed per ha. Their rice yields were still maintained (or even increased). Compared to the

[19] Average profit per hectare per crop of the targeted rice farmers increased from VND22.6 million before the project to VND29.6 million after the project (30.9% increase).
[20] A story on benefits of adopting improved rice farming practices by Ms. Le Dong Phuong from D2 hamlet of Thanh Loi commune, Vinh Thanh District of Can Tho City, is presented in annex 7, box 7.1.

previous traditional cultivation, this improved practice helped reduce seed cost by about 30–40 percent (or about VND 0.7 million per ha per crop, reduced from VND 2.2 million to VND 1.5 million per ha).

- **Fertilizer use reduction.** For about 93 percent of farmers who have applied this practice, the fertilizer cost has been reduced by an average of 35 percent compared to traditional farming (equivalent to VND 1.9 million per ha per crop, reduced from VND 5.5 million to VND 3.6 million per ha).
- **Pesticide use reduction.** For about 97 percent of farmers who have applied this technique, the cost of pesticides has decreased by 48 percent on average (equivalent to a reduction of VND 2.5 million per ha per crop, reduced from VND 5.1 million to VND 2.6 million per ha).
- **Irrigation water reduction.** About 99 percent of the farmers trained have applied the correct AWD irrigation technique, which helped reduce the water irrigation amount by more than 30 percent (from 7-8 times to 4-5 times of water pumping per crop). This has not only helped reduce production costs but also reduced GHG emissions.
- **Productivity increase.** As a result of the application of high-quality seeds, proper seeding rates, and proper fertilization and watering techniques, the average rice yield of targeted farmer households reached about 7.5–7.8 tons percent ha during the winter-spring crop 2021–2022 period (5–10 percent higher than the traditional farming).
- **Reduced post-harvest losses.** Following the project's support to FOs through matching grants to purchase additional equipment, dryers, and storages, the post-harvest loss rate of FOs was reduced by about 30 percent on average compared to before the project.[21] Based on the M&E data, 135,247 ha have achieved the two criteria in reducing irrigation water and post-harvest losses by 30 percent compared to traditional farming. This surpasses the target of 75,000 ha set for intermediate indicator B2 in the Results Framework.

Processing and Marketing

44. **Credit line.** The project provided medium- and long-term investment capital for ten rice milling or processing enterprises to purchase and upgrade rice milling, processing, and storage facilities to improve rice processing efficiency. Credits of US$97.3 million were provided under the project, of which US$33.3 million was financed by the IDA credit. An additional US$61.9 million was provided by the commercial banks participating in the credit component, and contributions from the end borrowers and the Revolving Fund amounted to US$2.1 million.

45. **Matching grants.** The project provided matching grants for purchasing machinery, equipment, and production infrastructure for FOs with an average amount of US$400,000 per FO, each FO comprising 500 to 1,000 rice farming households. The grant portion for FOs to buy additional goods and equipment was 30 percent, while for upgrading FOs' production infrastructure, it was 80 percent. During implementation, however, many FOs faced difficulties securing the required funding contributions, especially for buying goods and equipment. The list of eligible goods and equipment defined by MARD was also restrictive as it excluded, for example, transplanters and straw balers that were in high demand

[21] The postharvest loss rate from the FOs targeted by the project was reduced from 13 percent to 8 percent after investment in additional equipment, dryers, and storages.

by FOs. Further, a 50/50 fixed ratio of infrastructure versus equipment stipulated in the Government's Feasibility Study quickly depleted the funding allocated for much favored 'infrastructure' matching grants. The situation was further challenged by the weak interest of FOs in purchasing equipment for value chain development.

46. Consequently, during 2015–2020, for rice FOs in the MKD, only 91 FOs (out of 309 FOs) were selected to invest in production infrastructure and equipment with a total investment capital of VND 581 billion. This was considerably lower than the VND 1,155 billion anticipated at appraisal. The project support included 181 km of feeder roads, 16 km of canals, 53 pumping stations, 126 bridges/sluices, 39 temporary rice storage warehouses (with a total reserve capacity of 41,000 tons), 27 dryers (with a capacity of 40–80 tons per batch), 36 km of electricity lines, 73 transformers, and 12 transplanters. During the 18-month project extension period (January 2021 to June 2022), following the guidance of the MOF based on the Public Investment Law, the project diverted its direct support to FOs to supporting small-scale public investment infrastructure in the villages where the FOs supported by the project were located, including inter-commune and inter-cooperative works. The project supported 86 public infrastructure subprojects with a total investment of VND 1,096 billion, including 377 km of rural roads and 149 bridges, 8 km of irrigation canals serving 1,161 ha, 30 irrigation sluices serving 8,310 ha, and 19 pumping stations with a total capacity of 87,800 m^3/ha. Although these infrastructure schemes were classified as public, they mainly service the FOs and play an essential role in transporting goods from a district to villages by the FOs and other business establishments of the commune, facilitating value chain development.

Figure 4. The Logo of Ong Cua

The logo of Gao Ong Cua is displayed on the website of the U.S. Patent and Trademark Office. Photo by VnExpress/Dat Nguyen.

47. **Contract farming.** The project supported linking farmers with businesses to help sell rice produced by smallholders on about 74,234 ha. One of the high-quality rice value chains supported by the project was the 'Ruộng nhà mình' (My farm), developed by Viet Food Agricultural Product Chain Joint Stock Company in 2018 to source ST24 and ST25 paddy from the FOs supported by the project (the ST25 variety won the World's Best Rice Contest in 2019 and was awarded the Second Best in the 2020 Contest). Approximately 50 percent of domestic sales by Viet Food Agricultural Product Chain Joint Stock Company in 2021 were purchased from cooperatives participating in the VnSAT project, such as Tien Cuong Cooperative, Thuan Tien Cooperative, and An Binh Cooperative (500 tons of rice, equivalent to nearly 1,000 tons of paddy).

Coffee Value Chain Improvements

48. **Net profits increase.** For coffee farmers, the average profit increased by 22.4 percent compared to non-project households, reaching 112 percent and exceeding the end target of a 20 percent increase. The average profit per hectare of coffee farmers supported by the project increased from VND 55.3 million per year before the project to VND 69.2 million per year after the project (25.4 percent increase). This resulted from productivity increases, lower fertilizer use, and increased output price due to improved coffee quality.

49. **Capacity of FOs and cooperatives developed and strengthened.** For the coffee component, the project supported 202 FOs (with an area of 13 ha to 550 ha each) with establishment and capacity strengthening. Based on the project M&E data, 63,000 farming households have properly applied sustainable coffee farming practices on a total area of 70,446 ha in five Central Highlands provinces. Based on the M&E data, these activities have resulted in the following:

- **Reduced use of fertilizer and pesticides.** Eighty (80) percent of farmers that have applied sustainable coffee production processes have managed to save VND 1.51 million per ha from reduced use of fertilizer (reduced from VND 41.6 million per ha to VND 40.09 million per ha) and VND 1.6 million per ha from pesticide use reduction (reduced from VND 3.7 million per ha to VND 2.1 million per ha).
- **Use of water-saving irrigation.** The project supported the construction of 190 ha of drip irrigation demonstration models and 349 ha of root-zone sprinkler irrigation models. These models leveraged other households in the project area to invest by themselves in 595 ha of drip irrigation and 6,383 ha of root zone sprinkler irrigation (mainly in Dak Lak province).
- **Pilot application of smart irrigation Internet of Things (IOT) technology.** This activity was supported through an additional grant of the Korean Green Growth Trust Fund for pilots in Dak Lak and Lam Dong provinces. As a result, models have been installed for 44 households in an area of 75 ha. As per feedback received, the irrigation has been effective, especially in determining the timing of irrigation, quantifying irrigation water, and thereby further reducing operating costs of irrigation pumps and saving water.
- **Use of simple (manual) water-saving irrigation techniques.** In addition to advanced water-saving technologies, the project also encouraged farmers to apply simple manual irrigation methods that adhered to the criteria of saving water by reducing the number of watering times (reduced from more than five times down to three times or less) and the amount of irrigation water each time (reduced from 750 liters/ per tree down to below 400 liters per tree). By the end of the project, farmers in 93 percent of the project area have properly applied water-saving technologies on 54,000 ha (exceeding the project target of 22,000 ha). The application of water-saving technologies has reduced production costs, groundwater use, and erosion on sloping lands caused by excessive watering.

50. **Increased capacity of nurseries to produce high-quality coffee seedlings.** To support the coffee rejuvenation activities, the project had certified 51 nurseries that met quality standards. Following an upgrade of 11 state nurseries and 21 private nurseries, the upgraded nurseries have provided more than 12.6 million quality seedlings to farmers in the project areas to rejuvenate 12,000 ha of coffee. Along with ensuring the supply of quality seedlings, the Provincial Project Management Units (PPMUs) also required the targeted farmers to purchase seedlings at certified nurseries as a condition for disbursing loans for

farmers for rejuvenation. By ensuring the use of quality seedlings, most of the coffee replanting areas supported by the project (totaling 22,271 ha) have been rejuvenated with quality-controlled seedlings.

Processing and Marketing

51. **Matching grants.** The grant portion for FOs in the Central Highlands to buy additional goods and equipment was 50 percent and for upgrading FOs' production infrastructure, 80 percent. The coffee FOs faced the same challenges in applying for the matching grants program as those listed for the rice FOs in paragraph 45. As a result, the project could support only 42 coffee FOs out of 202 participating FOs with the matching grants in the total amount of VND 204.6 billion. This support included 85 km of access roads built in production areas, 36 coffee warehouses with a total capacity of 10,200 tons, 1,378 m^2 of covering houses for dryers, 11 km of power lines, five sub-stations, 209 coffee processing machines, and 34,000 m^2 of coffee drying yards. During the 18-month project extension, the project supported investments in 30 public infrastructure subprojects with a total investment amount of VND 510 billion, including the upgrades of 233 km of rural roads and 2 km of canals. With the Central Highlands' natural characteristics, the roads upgraded by the VnSAT will not only bring economic and livelihood benefits but will also support a coffee landscape approach, thereby creating more income for local farmers from potential ecotourism opportunities.

52. **Credit line.** A total of VND 2,050.23 billion (equivalent to US$89.14 million, including US$71.73 million from the project credit line and US$17.41 million from the Revolving Fund) was disbursed, financing 5,642 loans to grow and care for rejuvenated coffee in the Central Highlands with the total area of 11,932 ha, exceeding the target value of 9,000 ha. The initial allocation for the coffee credit line was US$50 million, but it was increased to US$71.73 million due to a higher demand for credit from the coffee producers. Impressively, an additional US$17.41 million was financed by the Revolving Fund, and US$48.5 million was leveraged through the PFIs and end-borrowers. The coffee farmers received preferential lower interest rates during the grace period (for the first four years) to soften the financial pressure of cash flows on their livelihoods, while rejuvenated coffee orchards have not yet generated income.

Figure 5. Landscape Coffee Brands Supported by VnSAT
(Source: CPMU's Project Photos)

53. **Contract farming.** The first landscape coffee value chain in Vietnam was launched with the participation of Golden Bean company (in PAN Group). The supply contract started in 2021 with Dak Nong Organic Agriculture Cooperative, and offtake contracts were subsequently signed with businesses covering 14,700 ha of coffee in the project area. Currently, Golden Bean's coffee product is sold by domestic distribution systems such as Bach Khoa Xanh, Post Mart, Winmart, Lazada, Shopee, and Shin

Coffee chain. It is expected that the product will be exported to the US and Korean markets in the coming years. All these products are branded as Landscape Coffee of the VnSAT.

54. **Several remaining challenges in improving rice and coffee value chains include** (a) effectively mobilizing know-how for advanced branding of better quality rice and coffee; (b) sustaining adequate control of seedling quality and farmers' access to good seedlings; (c) creating continued affordable access to post-harvest equipment, including through capacity development of FOs and a facilitated link to agribusiness (for example, through expanding contract farming arrangements); and (d) implementing the landscape approach that remains subject to a full commitment by the local government and local stakeholders.

PDO Part 3: Strengthened public agencies to effectively support implementation of the Agricultural Restructuring Plan

55. **The project's performance in reaching PDO Part 3 is rated *High*.** All indicators established under the Results Framework were achieved (see table 3). The subsequent paragraphs provide a more detailed review of the capacity improvements and fiscal strengthening achieved (a) at MARD; (b) at provincial level/DARD; and (c) by value chain partners, which together contributed to better public service delivery and hence enabled a more effective implementation of the ARP plan. The innovative concept of coffee landscape management was piloted as planned, which aimed to draw practical field experience and lessons in stakeholder engagement before they could be fully embraced and acted upon locally.

Table 3. PDO 3 and Intermediate Results Indicators: Baseline, Targets, and Actual Achievements

	Baseline	Target	Actual	Achievements (%)
PDO Part 3 Indicator				
Improved quality of service delivery by MARD and DARDs in support of project implementation as measured by performance scorecard				
(a) MARD (departments)	0	4	4	100
(b) DARDs (provinces)	0	10	10	100
Intermediate Results Indicators				
A1. Improved performance in budget execution by MARD measured by a reduction in the discrepancy between budget allocations and end-of-year budget out-turns (%)	0	20	30.6	153
A2. An MTEF covering MARD's investment and recurrent expenditure and MTEFs for DARDs	0	3	3	100
A3. Adoption of improved subsector ARPs in select MARD departments (departments)	0	3	7	233
C4. Number of pilot coffee-based landscape management plans developed in project areas (plan)	0	5	5	100

Note: MTEF = Medium-Term Expenditure Framework.

56. **Capacity strengthening for MARD was achieved.** The project supported the capacity building of MARD to facilitate the ARP 2017–2021 implementation process and hence also built the basis for facilitating the next ARP. This was accomplished through (a) the review and reform of policies that have

an enabling effect on better ARP implementation and the successful facilitation of the legislation process of key laws and decrees in the sector; (b) a better-performing budgeting process, including the preparation of a medium-term investment framework for MARD and DARDs; and (c) human resources development of public agencies at both national and provincial levels. The project has supported MARD in developing its human resources by financing the organization of 45 conferences, workshops, and training courses for national and provincial officials to consult about the development/dissemination of policies and legal documents in the context of the ARP, to communicate better the newly issued policies for restructuring and promote results-based management at governmental agencies.

57. **Review of policies and strategies and successful facilitation of reforms in the sector.** The project supported a series of policy and strategy reviews, including policies on agricultural land, science and technology, credit and loans, the ongoing ARP with its six subsectors (Fisheries, Forestry, Water, Crop Production, Livestock Production, Agro-processing, and Market Development), the National Food Security Scheme, and the Strategy for Livestock Development, and helped with the communication planning for the 2016–2020 ARP. These reviews were commissioned through MARD and have informed the preparation/revision of a substantial number of new or revised decrees, Prime Ministerial decisions, and national plans that helped reform the agricultural sector, including value chain arrangements and processes.[22] It is particularly noteworthy to mention the contribution of VnSAT in demonstrating the successful experiences in promoting sustainable low-carbon agriculture, which in turn helped bring a greater emphasis on green and sustainable agriculture in the new MARD Agriculture and Rural Development Strategy for 2021–30 with a vision to 2050. The strategy, in turn, has been translated into action into the new national 1 million ha high-quality and low-carbon rice program that builds on the experience of the VnSAT. Moreover, MARD is also working on accessing carbon payments from the VnSAT rice emission reductions achieved through the Transformative Carbon Asset Facility.

58. **Better-performing budgeting process and new medium-term investment framework (MTEF) for MARD and DARDs.** The project helped review and develop three MTEFs in agriculture—one for MARD and one each for the two pilot provinces, Lam Dong and Dong Thap. Based on the review, an MTEF for 2021–2025 and a three-year financial budgetary plan (2019–2021) were proposed and approved in line with the ARP. Overall, there is evidence (based on planned and actual budget allocations) that the budget execution performance was improved, measured by a reduced discrepancy between budget allocations and end-of-year budget out-turns of 30.6 percent against the end target of 20 percent (see also table 3).

59. **Strengthening of provincial public agencies achieved.** At the provincial level, the project developed the capacity of DARD staff for better ARP implementation, specifically in terms of results-based management, change management, risk management, value chain development, communications, and the development of medium- and long-term investment frameworks (see also indicator A2). Based on the borrower's separate report on the completion of Component A, in total, 33 training courses for about

[22] Including a plan for linking production and consumption of agricultural products between cooperatives, Union of Agricultural Cooperatives, and enterprises until 2020 in Plan No. 6390/KH-BNN-KTHT dated August 17, 2018; a new Livestock Development Plan - Decision No. 1368/QD-BNN-CN dated 1/4/2021; a comprehensive program for sustainable and climate resilience agricultural development in the MKD approved by the Prime Minister in the Decision No. 324/QĐ-TTg dated February 2, 2020; Resolution No. 34/NQ-CP dated March 25, 2021, on food safety assurance by 2030; Guidance for implementing the Fisheries Law (two decrees of the Government, one decision of the Prime Minister, and eight circulars of the Minister); the Law on Crop Production; and the Law on Livestock Production as well as legal documents to implement both (two decrees and seven Circulars);

1,800 participants were delivered. Post-training evaluation surveys of participants indicated that about 90 percent were satisfied with the quality and relevance of the training events.

60. **Capacity of selected value chain partners advanced.** In collaboration with the BIDV, the project improved the credit and financial management capacity of 188 credit officers from partner retail banks in the project regions. Advanced know-how about BIDV credit procedures and processes helped roll out the VnSAT line of credit component, thus reaching ten (10) rice processors and 4,502 coffee farmers. In addition, the project financed market and value chain studies in the coffee sector to inform and support public-private engagement within the Vietnam Coffee Coordination Board[23] to more effectively advise on coffee-related policy making. The project also supported technical departments of MARD in conducting 22 technical support packages to support rice and coffee value chains, including production zone planning, technology improvements, implementation monitoring, providing training to farmers and FOs/cooperatives, and conducting GHG emission measurements on rice farms. The technical support activities contributed to the success of the rice and coffee components and the impact has gone beyond the project provinces. The project's success was replicated and scaled up in other regions throughout the country.

Box 2. Quality of Public Administrative Services

- Visible means: External image of the web portal, staff behavior, documents and communication system, and safety and security level of the system
- Reliability: The ability to provide accurate, on-time, and reputable service; keep commitments; and keep promises
- Responsiveness: The ability to solve problems quickly, effectively handle requests and complaints, and be ready to help and respond to requests
- Assurance: The factor that creates trust and confidence for people through professional service, good knowledge, polite demeanor, and good communication, creating peace of mind.
- Sympathy: Considerate and thoughtful care and attention.

61. **Quality of service delivery by MARD and DARDs enhanced.** A study[24] was commissioned to assess the change in the quality of public service delivery by four MARD departments (Department of Agricultural, Forestry and Fishery Quality Assurance; Department of Plant Protection; Department of Crop Production; and the National Agriculture Extension Center) and of DARD services in 10 pilot provinces[25] selected to participate in the pilot study. The study concluded that all four MARD departments and ten (10) provinces have significantly improved public service quality compared to the project baseline assessment (in 2016 and 2017) and performed well on their scorecards that evaluated the pre- and post-project quality of service delivery. While the innovative methodology with a wide set of dimensions (see box 2) was used to measure the quality-of-service delivery by MARD and DARD, the scoring card would

[23] An advisory body officially established in July 2013, comprising representatives from MARD, selected PPCs, the Institute of Policy and Strategy for Agricultural Development (IPSARD), the private sector (for example, Vietnam Coffee and Cocoa Association [VICOFA], Atlantic Commodities Vietnam Ltd [ACOM]), and farmer representatives.
[24] MARD report on analysis and assessment of public service quality in agriculture and rural development sector (Phase 3).
[25] Provinces Vĩnh Phúc, Nam Định, Thanh Hoá, Hà Tĩnh, Lâm Đồng, Bình Định, Đồng Tháp, Quảng Ninh, Bình Dương, and Hà Giang.

have benefitted from a more balanced set of performance measures (including, for example, financial management performance, oversight and governance, and so on).

62. **Pilot coffee landscape planning.** The value of sustainable coffee landscape management has been embraced by pilot provinces only at the late stage of project implementation. Five coffee-based landscape pilot management plans were developed; however, it was rather late in the project timeline and only one was under implementation before the project closure. The whole task was implemented by the Southern Sub-Institute of Vietnam National Institute of Agricultural Planning and Projection (Sub-NIAPP) in coordination with the Western Highlands Agriculture and Forestry Science Institute in selecting locations for the model and conducting planning based on consultations with the local communities before submission of coffee landscape plans to MARD for approval. There was no evidence, however, that the plans were discussed with a broader circle of stakeholders, such as civil society and private sector representatives. After obtaining MARD's approval, the project provinces began mobilizing resources together with farmers to participate in the implementation of the landscape planning. It is expected that this activity will help preserve natural ecosystems and local cultural identities combined with the tourism industry to promote products, increase farmers' incomes, and increase environmental sustainability.

Justification of Overall Efficacy Rating

63. **Overall efficacy is rated 'High'.** The project effectively supported the efforts of the Government to implement its ARP as well as successfully demonstrate a model for sustainable agricultural sector transformation in Vietnam through the rollout of effective CSA solutions for growing rice and coffee. It delivered transformative green agricultural results and set the stage for the renewed national green growth agenda. To this end, the VnSAT made significant contributions to the development of new Government strategies to transition to low-carbon agriculture as listed in paragraph 57. The project brought benefits to almost 1 million rice and coffee farmers in the MKD and Central Highlands including increased productivity and farm incomes as well as reduced environmental pollution and GHG emissions in rice farming. The project also supported farmer cooperative development, leveraged impressive private investments under both rice and coffee credit lines and matching grant program, and improved FOs' capacity through strengthened cooperation and market links. Despite several challenges related to the implementation of the matching grants for FOs and delays in the preparation of pilot coffee landscape plans, the VnSAT fully achieved its objectives and exceeded all PDO and intermediate indicators. These achievements are remarkable, especially given that the last two years of the project implementation took place during the COVID-19 pandemic. Currently, MARD has internalized and integrated the VnSAT's success into its national coffee and rice programs to be replicated throughout the country.

C. EFFICIENCY

64. The VnSAT was approved in December 2015 with total funding of US$314 million, of which US$238 million was financed by IDA, US$12 million from the Government of Vietnam, and US$64 million from local contributions. By the project closing, the actual disbursements were US$211.7 million from IDA credit, US$29.3 million from the Government, and US$135.7 million from local contributions. The original project implementation period was from 2015 to 2020. The non-credit component was extended for 18 months until June 2022. The ex post economic and financial analysis (EFA) was based primarily on the observed quantifiable benefits at the level of the primary beneficiaries associated with rice and coffee

production[26] and the monetized quantification of GHG reduction. The analysis focused on results achieved until June 2022.

Summary of Results

65. The project's benefits included both quantifiable and non-quantifiable benefits. The major sources of quantifiable agriculture benefits included: (a) increased farmer productivity and profitability resulting from resource efficiency use; (b) increased farmer productivity and profitability resulting from access to improved infrastructure; (c) reduced GHG emissions from rice farming in the project area; (d) increased irrigated land value; and (e) reduced climate vulnerability to droughts through irrigation use. Other benefits that cannot be easily quantified in monetary terms included reduced negative environmental impacts on water and soil from crop production as well as the impact on other associated value chain actors that were not directly supported by the project.

66. The results from the analysis up to June 2022 showed that the economic internal rate of return (EIRR) of the overall project was 41 percent, and the net present value (NPV), discounted at 10 percent,[27] was US$511 million. The benefit-cost ratio, estimated as the NPV of benefits divided by the NPV of project costs, is 7.4. The financial internal rate of return (FIRR) of the overall project was 38 percent. The results by project component showed that the EIRR was 39 percent for rice and 45 percent for coffee. The results by region show that there were differences among them. Of those provinces in the MKD under the rice component, the internal rate of return (IRR) ranged from 24 to 71 percent. For the Highland provinces under the coffee component, the IRR ranged between 20 and 67 percent. Compared to the EIRR at appraisal, the EIRR at the project closing is higher (Table 4).

Table 4. Comparison of EIRR by Component between Project Appraisal and Closing (Percentage)

Project/Component	At Appraisal	At Closing
Project	24	28
Component B1 (Rice)	32	36
Component B2 (Rice)	24	36
Component C (Coffee)	18	20

Sensitivity Analysis

67. A first set of scenarios included a scenario where the rice component only considers the GAP rice investment, and the second scenario evaluated the impact of the rice mill investment. This setup allowed to isolate the impact of the GAP rice investments (3R3G and 1M5R processes) from the rice mill investment. The project EIRR increased slightly to 28.3 percent (only 0.4 percent) with a higher NPV at US$426.2 million with the rice mill investments. That is, with the rice mill investments, the project has overall improved economic indicators.

[26] The project's main benefits came from Components B and C supporting smallholder rice and coffee production systems (see paragraph 55 of the PAD).
[27] The economic analysis was undertaken in 2022 constant prices and a discount rate of 10 percent was assumed in accordance with the World Bank project guidelines.

68. A second set of scenarios analyzed the impact of the monetization of GHG emission reduction under a low carbon price and a high carbon price scenario. The results showed that when the monetized benefits of GHG emissions reductions in rice production were included, the overall project IRR increased to 57 percent under a low carbon price scenario and 96 percent under a high carbon price scenario relative to the GAP rice investment scenario. The NPV increased to US$736.8 million (low price) and US$1,155.4 million (high price). For the rice component, the EIRR was 120 percent assessed at a low carbon price and 231 percent at a high carbon price. The NPV increased from US$426.2 million under the standard scenario to US$640.2 million under a low carbon price and up to US$1,058.8 million under a high carbon price.

69. At the provincial level, the IRR increased substantially as well, especially for some provinces, where IRR surpassed 100 percent (An Giang, Can Tho, Dong Thap, Kien Giang, and Long An). The other three provinces showed an IRR ranging between 31 and 81 percent. The largest gains in NPV corresponded to Long An, An Giang, Can Tho, and Dong Thap, adding to almost 60 percent of the total change in NPV. Refer to annex 4 for a detailed description of the EFA.

Assessment of Efficiency and Rating

70. **Efficiency is rated 'High'**, based on the results of the ex post cost-benefit analysis reported above, which in aggregate show that the investment in the VnSAT generated robust returns.

D. JUSTIFICATION OF OVERALL OUTCOME RATING

71. **The overall outcome is rated 'Highly Satisfactory'** based on the ratings of High for Relevance, High for Efficacy, and High for Efficiency.

- **Relevance.** There were no shortcomings in relevance to the Government strategies, as well as to the World Bank Country Partnership Strategy for FY12–16 (CPS)[28] at the time of preparation and to the CPF and the Government's new Agriculture Strategy at project closing, and there is clear evidence of alignment of the PDO to the original CPS and the current CPF strategic objectives.
- **Efficacy.** Despite a few shortfalls, as described in the Efficacy section, the project fully achieved its intended outcomes, and most performance indicators were exceeded.
- **Efficiency.** The project generated attractive returns on investment as measured by ex post cost-benefit analysis, and sensitivity analysis suggests these returns can be considered robust under a range of plausible scenarios. The project demonstrated that triple economic, environmental, and low-carbon goals could be achieved simultaneously. This model can be replicated in other value chains and regions. The project created a strong foundation for Vietnam's agriculture sector to move into a sustainable and low-carbon pathway. More importantly, the VnSAT is a truly global flagship project as it generated several good lessons on 'green' agricultural transformation that shall be disseminated internationally (more details in section V Lessons and Recommendations).

[28] Vietnam - Country partnership strategy for the period FY12-FY16 (English). Washington, D.C. : World Bank Group (Report No. 65200-VN).

E. OTHER OUTCOMES AND IMPACTS

Gender

72. **Monitoring the participation of women in the project was limited to tracking one indicator, 'Number of Project Beneficiaries', disaggregated by gender.** The total number of direct beneficiaries of the project was estimated at 983,407, with 713,480 targeted in the MKD provinces and 269,927 in the Central Highlands provinces. The share of women beneficiaries was roughly estimated at 50 percent as they comprise half of the total number of project beneficiaries reached by the project. Female participation in project activities varied from 25 to 35 percent on average. These participation rates were equivalent to the average rate of women participating in agriculture in Vietnam. Women's participation in (a) project training and workshops averaged 30 percent in the Central Highlands provinces and 25.7 percent in MKD provinces; (b) public consultation meetings averaged 35 percent and 26.4 percent in Central Highlands provinces and MKD provinces, respectively; (c) membership in cooperatives averaged 20 percent in both Central Highlands and MKD regions; (d) agricultural extension models averaged 39 percent in Central Highlands provinces and 29.7 percent in MKD provinces; and (e) monitoring project activities averaged 35–70 percent in Central Highlands provinces and 20–35 percent in MKD provinces. Based on the BIDV report on the performance of the credit line, 20 percent of the end borrowers were women, and 25 percent of the end borrowers were ethnic minorities. A story by Ms. Nguyen Thi Thuy Trang is provided in box 7.2, annex 7, to show one of the VnSAT's impact stories by women beneficiaries.

73. **The project attached importance to the participation of ethnic minorities.** The VnSAT covered 13 provinces, of which 5 provinces in the MKD (Can Tho, Hau Giang, Soc Trang, Kien Giang, and An Giang) and 5 provinces in the Central Highlands (Kon Tum, Gia Lai, Dak Lak, Dak Nong, and Lam Dong) included ethnic minorities. Especially majority of coffee farmers in the Central Highlands were ethnic minority groups, and they were among the primary beneficiary group targeted by the project under the coffee component. The project helped ethnic minority groups improve their incomes by adopting sustainable farming practices. It also helped improve their competitiveness and long-term livelihoods' sustainability and stability. It is estimated that 36,200 ethnic minority people benefited from the project, mainly Soc Trang (over 11,000 people) and Gia Lai (over 4,600 people). Ethnic minority people in these 10 provinces participated in training on 3R3G/1M5R for rice cultivation, sustainable coffee production/replanting techniques, communication/community consultations, and working for and benefiting from the civil works. The project also contributed to the improvement of the rural infrastructure such as rural roads that facilitated the transport of rice and coffee produce to the market, which also eased the travel and daily activities of ethnic minorities.

Institutional Strengthening

74. **The project contributed to institutional strengthening at various levels: farmer/cooperative level, regional/provincial government level, and national level:**

- At the farmer and cooperative levels, new FOs have been established and existing cooperatives consolidated. These FOs are now better trained to conduct collective actions to improve production and manage cooperatives and have stronger links with agribusinesses to improve farm produce marketability.

- At the regional/province level, the institutional capacity of the DARD staff has been strengthened. DARD staff are better trained and equipped to effectively implement the ARPs and deliver public services. In addition, the project has strengthened decentralization. By delegating implementation of the ARP agenda and associated strategic planning, decision-making, and day-to-day management and implementation of the VnSAT, it has empowered the regional/province actors and assigned them a greater role in the allocation of public resources.
- At the national level, capacity building of MARD has enabled MARD to (a) improve its fiscal performance through increasing the effectiveness of the budgeting process, as well as through the preparation and use of MTEFs; (b) develop and implement ARPs for subsectors under MARD; (c) develop policies that serve sector restructuring; and (d) increase technical capacity at the central and local levels to shift to climate-smart and low-carbon agriculture.

Mobilizing Private Sector Financing

75. Under the matching grant program, the project mobilized US$4.9 million from FOs. This was the contribution by FOs to build warehouses and processing and post-harvest facilities, purchase equipment and upgrade their production facilities and infrastructure. Further, the project's credit line mobilized US$61.93 million from the PFIs/end-borrowers and created a US$2.11 million Revolving Fund for lending to rice processing enterprises to upgrade milling factories, warehouses, and drying capacity. Under the coffee credit line, the project attracted US$48.85 million from the PFIs/end-borrowers and produced a US$17.41 million Revolving Fund. Although VnSAT did not require a specific funding rate for a subproject, the BIDV always encouraged PFIs to properly structure the funding ratio between the VnSAT, PFIs, and end-borrowers. Especially for rice sub-loans with high values and high levels of risk, the contribution of funds from PFIs and end-borrowers of subprojects increased their responsibility and helped the VnSAT to have good quality subprojects. Based on the BIDV's Comprehensive Report, as of June 30, 2022, the funding rate of the VnSAT Credit Component reached about 53 percent of the total cost of subprojects, and PFIs' additional funds and end-borrowers' contribution accounted for 47 percent. This shows that VnSAT funds not only increased the responsibility of project participants in loan management but also served as an effective leverage for retail banks, rice enterprises, and coffee farmers to increase investments in subprojects for production and business development.

Poverty Reduction and Shared Prosperity

76. Approximately one million local beneficiaries directly benefited from the project support. While the project did not specifically aim to reduce poverty, this ICR presents evidence that project-financed activities have led to increased productivity, lowered production costs, and improved net incomes for rice and coffee producers in the MKD and Central Highlands. Rice value and profit from rice farming are generally low compared to other commodities, meaning that most rice producers are from the lower income groups; and the majority of coffee producers are ethnic minorities, many of whom also fall in the lower income categories. Generally speaking, they are among the poorest groups in rural areas. The livelihoods of these producers are getting more difficult due to the rising costs of agricultural inputs and market price fluctuations. The strengthening of the rice and coffee value chains and the improvement of processing capacity through the project have helped to stabilize their livelihoods and incomes, especially

during the COVID-19 pandemic, and created more upstream and downstream jobs for the residents in the project area and are thus expected to contribute to reducing poverty in these areas.

Other Unintended Outcomes and Impacts

77. With its success, the project pioneered some of the thinking around agricultural development and influenced the World Bank's agricultural transformation development agenda as documented in a range of presentations and documents, notably the (2022) analytical report 'Spearheading Vietnam's Green Agricultural Transformation: Moving to Low-Carbon Rice,' which suggests Vietnam can transform the rice sector by cutting GHG emissions, improving resource efficiency and yields, boosting resilience, and diversifying production. Such transformation will require significant investment and major policy reforms to align incentives and coordinate behaviors of stakeholders at all levels.

78. The project took advantage of some of the World Bank-supported research pilots in rice and coffee farming. In 2017, through a regional Korean Trust Fund, the World Bank supported a few innovations/IOT pilots in rice farming in the MKD, which was implemented by Tra Vinh University and MimosaTek Company. In late 2018, through its own funds, the World Bank continued a few IOT pilots in coffee farming in the Central Highlands. These pilots focused on analyzing daily water needs and advice on optimal water management; recording the time of irrigation and calculating water volume applied over time; saving water and fertilizer input uses; and reducing labor and production costs. The results from these pilots were scaled up under the VnSAT.

79. The improved technology packages for rice production also stimulated improved use of byproducts, the husk and the straw, after harvesting the rice. Some FOs started to use the straw byproduct for mushroom production, and after mushroom production, rice straw was used for producing organic fertilizers, thereby diversifying their income sources. Those FOs that entered into the primary processing of paddy with the help of the project took advantage of selling the husk for other commercial uses. Finally, the adoption of straw rollers made the traditional open straw burning practice after harvesting obsolete and thereby helped avoid air pollution and GHG emissions.

80. Several districts that benefitted from the project investments in the construction/rehabilitation of communal roads have been upgraded to a 'New Rural Development' status, which in turn triggered priority investments in these districts by the Government.

81. The International Finance Corporation (IFC)-funded Ag Tech Vietnam Project—that is currently under implementation and aims to improve smallholder farmers' access and application of agricultural technology and innovation—has recently reached out to the VnSAT's farmer cooperatives in the MKD to introduce its new app that is applied to coffee, pepper, and rice crops. The app is expected to serve two primary beneficiaries: farmers (who use the app as an electronic farming diary, changing manual recording habits and moving toward sustainable farming practices) and businesses (who monitor, supervise, and guide farmers to cultivate and use agricultural materials, improve supply chain management, and contribute to ensuring production sustainability). IFC is also preparing to work with commercial banks and rice processors in the MKD. Some commercial banks are highly interested in financing low-carbon and sustainable rice production in the MKD and have approached IFC to seek financial and technical assistance to support their rice value chains. The World Bank VnSAT team is cooperating with the IFC team to provide

information to interested commercial banks and agribusinesses on GAP and to look for opportunities to engage them in the proposed follow-on low-carbon agricultural value chain program.

82. Finally, the project contributed to the institutional strengthening of the banking sector, which helped enhance agriculture financing and the quality of agriculture lending. The VnSAT successfully aligned the technical support with the line of credit to support the coffee rejuvenation program. Through training of the staff of the commercial banks, the technical capacity of their credit officers was improved, especially in the appraisal of agricultural projects, and their risk appetites and perceptions also changed. In a consultation workshop with the PFIs at project closing, all of them expressed their willingness and plans to expand their lending portfolio for agriculture in the coming years. The project's model of using a wholesale bank to train and monitor the lending quality of retail banks also proved more effective than working with each retail bank directly. This model also enhanced healthy competition among retail banks to accelerate disbursement and improve lending quality.

III. KEY FACTORS THAT AFFECTED IMPLEMENTATION AND OUTCOME

A. KEY FACTORS DURING PREPARATION

83. **Objectives and concept.** The project concept was timely as it arrived at a time when the impressive growth of the agricultural sector and its export competitiveness were threatened by environmental degradation and climate change impacts. The PDO was realistically formulated and was well aligned with the Government's sectoral priorities. Project preparation was sound and took place in the form of a dynamic and cooperative process with MARD and province authorities. Intensive stakeholder interaction during preparation created a strong buy-in for the project's technology and institutional innovation approach. The project design was informed by the rich amount of analytical work of the World Bank combined with the experience of the previous World Bank-funded Agriculture Competitiveness Project (ACP, P108885) that quantified the impacts on profitability and on the environment from a package of '3R3G' and '1M5R' agronomic practices for growing rice. With regard to coffee rejuvenation, agronomic practices for grafting were well established, and analytical work on protocols for uprooting and replanting was undertaken as part of the project preparation. These technologies were already successfully piloted by the Government and development partners at the time of project preparation and were part of the national extension strategy. The VnSAT was designed specifically as a technology dissemination and diffusion project with the aim to scale up these environmentally sustainable farmer practices in more expanded rice and coffee production areas.

84. **Risks and M&E system.** The overall risk of the project at appraisal was conservatively assessed as substantial. The main risks were associated with: (a) project complexity derived from the need to build synergies among previously disconnected initiatives and stakeholders; (b) the political economy factors affecting implementation of the broader ARP upon which the VnSAT was anchored; and (c) possible deterioration in the external markets for higher-value rice and/or coffee from volatility in world prices. In anticipating these risks, the Government and World Bank's project team prepared and implemented an appropriate implementation support plan to identify difficulties as early as possible. Therefore, these risks did not materialize during project implementation. The design of the project's M&E system was generally sound. The system put in place for collecting, verifying, and reporting M&E data was comprehensive and internally consistent. Dedicated M&E staff based in the Central Project Management Unit (CPMU) in Hanoi

were supported by M&E specialists based in the PPMU (provincial) offices. This ICR, however, identifies a few shortcomings in the Results Framework and offers some possible solutions/alternatives for the project team (see details in Section IV.A).

85. **Project design.** Although the project was well designed in its overall effort to support the process of agricultural modernization in Vietnam and the associated processes of institutional and regulatory strengthening and reforms, some of the project elements caused delays and inefficiencies during implementation. Specifically, they were related to: (a) coffee landscape planning; (b) the 50/50 allocation of project matching grants for infrastructure vis-à-vis goods and equipment (while this initial allocation was only indicative, it was interpreted rigidly, causing significant delays during project implementation when demand for infrastructure support was higher than for equipment); and (c) restrictive list of equipment for FOs prescribed in the Government's Feasibility Study (see details in the next section 'Key Factors During Implementation').

B. KEY FACTORS DURING IMPLEMENTATION

86. **The concerned government agencies were highly committed, engaged, and well-coordinated during project implementation.** The implementation arrangements were well designed, with MARD being the executing agency for the project. The distinct feature of effective implementation of Component A was that it was led and executed by MARD's Department of Planning in close coordination with other MARD departments/directorates. CPMU was the key project implementing agency at the central level and was responsible for the overall project coordination across all targeted provinces including M&E. At the provincial level, the Provincial People's Committees (PPCs) and DARD offices were in charge of project implementation. The PPMUs established under DARDs were responsible for project coordination, including fiduciary and M&E functions, and safeguard compliance. Since the agricultural technologies promoted by the VnSAT were already part of the national extension strategy, their rollout was easily facilitated by the staff of DARDs and PPMUs.

87. **Throughout project implementation, the project suffered from frequent interruptions in IDA allocation to provinces.** This, in fact, was a portfolio-wide issue in Vietnam, where the tighter public debt management resulted in rationing of the ODA funds for the World Bank projects under implementation. The VnSAT was not an exception and experienced particularly serious delays in budget allocations in 2017 and 2019 that slowed the pace of project implementation and disbursements.

88. **Another project challenge was the slow implementation of the FO subprojects.** This was mainly due to the late allocation of annual budgets during the project lifetime (see the above paragraph). Further, the 50/50 ratio of matching grants allocated to infrastructure and goods/equipment for FOs proved ineffective during project implementation as most FOs preferred infrastructure to equipment. In addition, the contribution share to a matching grant, as prescribed by the MOF (70 percent by the rice FOs and 50 percent by the coffee FOs), to finance FOs' goods and equipment was high and many FOs were not able to secure the required counterpart funding. The list of eligible equipment for purchase originally set by MARD was also restrictive and excluded such items as transplanters and straw rollers that could have been helpful for the project's technology adoption purposes. This problem was addressed and fixed by MARD in August 2016. Other common problems included the weak capacity of some FOs to prepare investment proposals and ensure their timely approval by provincial departments and PPCs. To fully

support the eligible FOs and further strengthen project impacts, the project closing date was extended for 18 months, from December 31, 2020, to June 30, 2022.

89. **A new Public Investment Law introduced in 2020 limited the use of the IDA funding for training and capacity building, as well as for direct support for FOs.** The new Public Investment Law stipulated that after 2020, ODA capital must not be used to finance recurrent expenditures for soft activities including training, workshops, and consultations as well as direct support of FOs. To comply with the new Public Investment Law, during the project extension period (from January 2021 to June 2022), MARD and project provinces had to: (a) use their counterpart funds for implementing training and capacity building activities, (b) shift from direct support for individual rice and coffee cooperatives through matching grants to the public investment infrastructure subprojects which aimed to target both FOs and local communities.

90. **The credit line, which had slow uptake at the initial stage, was more favored by the coffee producers.** Initially, implementation of the credit line for both rice and coffee components lagged as a result of either market deterioration (decline in global prices for rice and weaker demand for Vietnamese rice) and consequent drop in demand for fixed asset loans (for rice), delays in activities by PPMUs, and deficiencies in credit line design for coffee (technical requirements related to technical and economic norms in coffee lending, upgrading standard nurseries, and so on). The pace of disbursement of the credit line gradually picked up and even accelerated by the project midterm stage with greater demand for the coffee credit line. To respond more effectively to real market demands, a decision was made at the midterm review (MTR) to provide more flexibility in the allocation and mobilization of IDA funds between the two credit lines for rice and coffee (the initial allocations were US$55 million and US$50 million, respectively). Following the MTR recommendations and formal request from the BIDV, the MOF amended the On-Lending Loan Agreement that merged the amounts of IDA credit allocated for rice and coffee. Although the credit line was not extended after December 31, 2020, the project continued to extend credits through the Revolving Fund from loan repayments.

91. **The project progress was at times affected by limited capacity of implementing agencies in some provinces.** The project covered 13 provinces in two geographical clusters (the Central Highlands and MKD regions), so project supervision and monitoring were more difficult and complicated overall. The late allocation of budget and the MOF's regulations which limited the use of ODA funds for recurrent costs and soft activities further constrained effective operations of the CPMU and PPMUs. These included: (a) slow preparation of implementation plans for FOs; (b) slow appraisal/approval of technical and economic reports for FO's subprojects by provincial authorities; and (c) weaknesses in implementing capacity building for FOs. It was also noted that implementation progress was uneven among provinces and components.

92. **COVID-19 pandemic.** COVID-19 outbreaks first occurred in Vietnam in early 2020, resulting in the country's partial and local lockdowns until June 2021. Due to travel restrictions and quarantine regulations, the project's field activities were largely suspended during this period. This caused delays in preparing technical designs and investment documents for FO subprojects as well as implementing construction activities under ongoing contracts. Project beneficiaries were also affected by negative impacts on consumer prices and the affordability and availability of some agricultural inputs and construction materials due to global supply chain disruptions during the COVID-19 period.

IV. BANK PERFORMANCE, COMPLIANCE ISSUES, AND RISK TO DEVELOPMENT OUTCOME

A. QUALITY OF MONITORING AND EVALUATION (M&E)

M&E Design

93. **ToC.** The three main results thrusts were clearly laid out: (a) strengthening the performance of (mainly) public agricultural institutions at the national and provincial levels; (b) developing rice-based and coffee-based production systems through scaling up the adoption of improved farm-based production and management technologies, plus the organization of FOs, and providing them with matching grants to improve access to collective harvesting and primary processing equipment; and (c) providing access to credit to upgrade rice processing technologies and facilities and rejuvenate coffee plantation to promote the performance of the value chain. The underlying causal assumption in aligning intervention support for farmer training on the one side and FO support on the other side—the way it was envisioned in the ToC (see figure 1)—was somewhat challenged by the slow implementation of the project matching grants program (see paragraph on FOs in 'Key Factors During Implementation').

94. **Results Framework.** While each of the PDO indicators on their own is meaningful for tracking the achievement of development outcomes, a few of them only partially reflect progress toward the achievement of the PDO.

- **PDO Indicator 3 (Net profits per hectare among targeted farmers).** The second element of the PDO statement, that is, 'value chain improvement', lacks a valid indicator in the Results Framework. While an 'increase in net profits per hectare among targeted farmers' is one desirable long-term benefit of 'value chain improvement', the project's longer-term intention has been to economically and environmentally 'upgrade' the value chain. This would comprise a product, process, and functional upgrading, that is, better or new (environment-friendly) products and processes, more complex functions within the chain (for example, in terms of post-harvest processing), and the participation in new activities or links with new/different chain actors. An additional PDO indicator measuring the change in the amount of paddy (in tons) sold by participating FOs may have been added to measure the backward and forward links in the rice and coffee value chains.
- **PDO Indicator 5 (Improved quality of service delivery by MARD and DARDs in support of project implementation as measured by performance scorecard).** The validity and reliability of this measure fully depend on the design of the scorecard and methodology applied for generating the composite score (see box 2, paragraph 61, which provides a list of variables considered in the composite score). While the approach taken was to focus on a sample of the most relevant institutions in the context of the project, the methodology used to measure this indicator could have benefitted from a more balanced set of performance measures (including, for example, financial management performance, oversight and governance, and so on).

95. **M&E arrangement.** The project split M&E responsibilities into three parts: (a) M&E for Component A carried out by the Department of Planning with support of external consultants; (b) M&E

of Components B, C, and D (excluding GHG monitoring) led by the CPMU with a network of provincial PPMUs at DARDs and BIDV focal points (for the credit line subcomponent); and (c) GHG emission measurement of rice-based systems in the project area conducted by an external institution. Internal M&E data were collected by PPMUs from the FOs' records and self-assessments. The 'independent assessments of farmer adoption' were commissioned by each PPMU to validate the regular data collection based on the farm recording books kept by farmers. Each PPMU procured the services of one consulting firm to implement this work according to the agreed terms of reference. The 'independent assessment of farmer adoption' was used as an alternative term for the 'Independent Technical Audit' mentioned in the PAD (p.54/paragraph 55), although the latter captured better the activity conducted.

M&E Implementation

96. **Comprehensive M&E Manual guided implementation.** The CPMU prepared a comprehensive M&E Manual that detailed the roles and responsibilities in: (a) monitoring progress at the central, provincial, and district levels; (b) consolidating data and reporting through the PPMU upward to the CPMU; and (c) commissioning baselines, reviews, adoption, and other studies. It also provided detailed guidelines for the measurement of each indicator agreed upon in the Results Framework, which was followed at all levels. The CPMU integrated data obtained from the PPMUs and consequently submitted semiannual progress reports with substantial quality to the World Bank. Completion of activities and outputs were tracked in detail. The project has also produced several final reports of high quality, including the borrower's Project Completion Report, BIDV's Comprehensive Report on the Project Credit Line, and the Final Report on the Implementation of Component A. Much effort went into tracking the application of the promoted technology packages by farmers. Participating farmers were required to manage a logbook and document all their field activities and yields. Semiannual sample surveys collected information on farmers' technology adoption against defined criteria. The M&E arrangement with a split of M&E responsibilities worked well; it was governed by a strong M&E plan, the appointment of designated M&E staff and external expert consultants at all levels, and an effective consolidation of progress and results information.

M&E Utilization

97. **Adaptive management.** During regular project review meetings, disaggregated progress and results measures helped identify advancement and delays as well as local strengths and weaknesses in delivering project activities. Detailed action plans were prepared and monitored to manage project implementation adaptively. Yet, there were certain areas where more critical analysis of monitoring findings could have helped better advance and sustain results by actively learning and changing support behavior based on monitoring results. An example is 'technology adoption.' Since the CPMU M&E staff strictly followed the adoption criteria set in the Project Operational Manual prepared at the project's onset, the project missed the opportunity to incorporate experiences from local farmers and local extension staff during project implementation. This not only discouraged local innovations but also, in some cases, slowed down the project implementation as the extension messages provided were not always appropriate for some local conditions. Further, the presentation of progress and results data by province and district during progress reviews was used to implicitly benchmark the performance of provinces and their PPMUs. This had a motivational effect on provincial teams. Finally, the monitoring of technology application was central for measuring the performance of Subcomponents B1 and C1. In

addition, the information fed into the rollout of other project activities. For example, only 'adopting' farmers had access to matching grant financing for rejuvenation of coffee gardens.

Justification of Overall Rating of Quality of M&E

98. The overall quality of M&E is rated 'Substantial'. The planned M&E agenda was sound albeit with a few shortcomings in the original M&E design, as described above. Monitoring was strong and data were well-utilized. The project achievements and lessons learned were well captured in the Government and BIDV's completion and project impact evaluation documents. The project M&E team is to be commended for a high sense of accountability and ownership.

B. ENVIRONMENTAL, SOCIAL, AND FIDUCIARY COMPLIANCE

99. **Environmental.** The project was classified as a Category B project (partial assessment), with an anticipated positive impact on the environment through adopting good agriculture practices in rice and coffee production in project provinces. The negative impacts anticipated were mainly related to civil works and were considered limited, localized, manageable, and reversible; these impacts would be minimized through proper design and application of mitigation measures. The project triggered three environmental safeguard policies including Environmental Assessment (OP 4.01), Pest Management (OP 4.09), and Physical Cultural Resources (OP 4.11). During project preparation, MARD prepared two Environmental and Social Management Frameworks (ESMFs) to guide the project in screening, assessing and mitigating project environmental and social impacts: one for direct project financing (non-credit activities) developed by MARD and the other for financing through a financial intermediary (banks loans) developed by BIDV. They were in accordance with the World Bank safeguard policies, as well as with Vietnamese laws. The ESMFs were disclosed locally at the project sites, the PPMUs, and the Vietnam Development Information Centre (in Vietnamese), and the Bank's InfoShop on November 4, 2014, for public access.

100. All infrastructure subprojects proposed by local beneficiaries were subject to environmental and social screening, followed by an Environmental Code of Practice (ECOP) report prepared for each subproject according to World Bank procedures to mitigate construction- and operation-related impacts. These ECOP reports were consistent with the national laws and World Bank environmental safeguards requirements. Regarding pest management**,** the project did not finance the procurement of agrochemicals, pesticides, and herbicides and followed existing MARD's Integrated Pest Management (IPM) packages. Screening of physical cultural resources was applied to all subprojects. A "chance finds" clause was included in ECOP and construction contracts. Both rice and coffee farmers were fully aware of the required application of GAP in rice and coffee production. For the credit lines, the BIDV provided training and guidance to the PFIs on the project's environmental safeguards and ensured that approvals were obtained from provincial authorities and that routine monitoring of environmental management and projection plans was carried out as part of lending requirements to rice processing mills. The CPMU also organized training and shared experiences in implementing environmental safeguards for the BIDV and PFIs. No incidents or complaints on environmental risks and impacts were reported by project closing. Overall, the project was in full compliance with the World Bank's environmental safeguards and the Government's environmental regulations.

101. **Social.** The project triggered two social safeguard policies, Involuntary Resettlement (OP 4.12) and Indigenous Peoples (OP 4.10). During project preparation, MARD prepared the Resettlement Policy Framework (RPF) and Ethnic Minority Policy Framework (EMPF) in accordance with World Bank social safeguards requirements. These documents were also disclosed locally at the project sites, the PPMUs, and the Vietnam Development Information Centre (in Vietnamese), and the Bank's InfoShop on November 4, 2014, for public access.

102. During project implementation, the project did not cause any displacement. Land acquisition of all subprojects in 13 provinces was of small scale and in most cases, took place on public land. Land acquisition occurred only when all affected households voluntarily donated their land, and this practice followed the World Bank's policies. Consultations were carried out properly with local beneficiaries and affected people, including ethnic minorities and female participants. The affected people also fully understood the project's compensation policy and the entitlement to compensation before making their decisions. Overall, the project fully complied with World Bank's social safeguards and the Government's regulations.

103. **Procurement.** Despite delays in procurement at the initial stage of project implementation, no major procurement issues were observed during the project's lifetime. The bidding and procurement activities were divided into two phases: (a) Phase I (2015–2020), in which bidding and procurement activities included mainly the selection of consultants to support project implementation, and in the provinces involved the preparation of bidding and procurement activities mainly for small packages of goods and works supporting FOs, and (b) Phase II (the project's extended period to June 2022), in which bidding and procurement activities in provinces were mainly for public investment infrastructures packages with a larger scale than under Phase I. All works contracts in Phase II were completed in the extended period. Overall, the procurement performance by the CPMU and the PPMUs on compliance was satisfactory.

104. **Financial Management.** The financial management (FM) reviews in regular supervision missions identified that an adequate FM system was in place that could provide, with reasonable assurance, accurate and timely information that the World Bank loan proceeds were being used for the intended purposes. The project FM rating was consistently rated as 'Moderately Satisfactory' since 2016. The reviews also recognized adequacy of FM staffing, accounting, and internal control systems, and maintenance of supporting documents in the project. The project audited reports and interim financial reports were submitted with acceptable quality but often late due to the large volume of consolidation works. The independent auditors have audited the project financial statements annually. The audit team of the MARD's Agricultural Project Management Board performed internal audit activities in all project implementing agencies and shared their internal recommendations. The CPMU and PPMUs fully carried out both internal and external audit recommendations.

C. BANK PERFORMANCE

Quality at Entry

105. The World Bank team made a strong effort to design a project that was aligned well with the Government's desire to transform and modernize the agricultural sector, not only by strengthening capacity in the public sector but also by promoting environmentally sustainable solutions for farmers,

providing access to finance, and linking them with private operators and markets. The institutional arrangements, which ensured a strong presence at the provincial level, were designed to support the Government's decentralization agenda. The project design was informed by the rich analytical work on 'greening' rice and coffee built by the World Bank as well as by lessons learned from previous projects. The inclusion of such prominent and reliable institutions as the IRRI to provide technical assistance under Component B and BIDV as a wholesale bank for the credit line contributed to project success. The soundness of the design and the implementation arrangements is reflected in the fact that despite initial delays in start-up, the project met all its development objectives and exceeded many of its outcome targets. Despite the strengths of the project design and planned implementation arrangements, there were minor shortcomings at entry. As mentioned earlier, the Results Framework showed a few weaknesses related to the PDO elements on measuring 'net profit per ha' and 'improved quality of public service.' Also, more effort had to be envisaged at the project design stage to support FOs and the heterogeneity of the physical, climatic, and socioeconomic context of the coffee production areas.

Quality of Supervision

106. The World Bank team that supervised the project provided close and effective support throughout implementation. Noteworthy features of the supervision effort included the following: (a) regular supervision missions: the World Bank task team organized 13 supervision missions, which included regular field visits except during the COVID-19 pandemic period; (b) continuity in leadership (one of the task team leaders (TTLs) supported the project throughout seven years of implementation); (c) in-country presence (the TTLs and most other members of the multi-disciplinary task team were based in Vietnam and were able to provide close, continuous support to MARD and the CPMU); and (d) close collaboration with the Finance, Competitiveness and Innovation Global Practice in provision of implementation support for the project's credit line. Having the TTLs in the country office also enabled smooth project implementation support during the COVID-19 pandemic, especially when travel to Vietnam was restricted. The World Bank team provided continuous and effective monitoring and was flexible in its responses to any unforeseen changes or difficulties. This was particularly important because the project operated in a dynamic market environment and the selected rice and coffee subsectors encountered changes in their business environment which needed to be addressed. In response to the evolving internal and external circumstances, the team restructured the project, extended the closing date, and reallocated/cancelled loan proceeds. Finally, owing to the efforts of the project team, the VnSAT has become a platform for global research and knowledge.

Justification of Overall Rating of Bank Performance

107. Overall, the World Bank performance is rated to be Satisfactory. The project was highly relevant to the country's needs and fully in line with the World Bank and country policies. It was well prepared (recognizing a few shortcomings at the design stage), highly visionary about the GHG reduction pathways, and innovative and relevant and followed all the necessary safeguards. It was professionally and continuously supported during implementation and corrective measures were taken whenever necessary.

D. RISK TO DEVELOPMENT OUTCOME

108. Vietnam is among the most vulnerable countries to climate change, including sea level rise, droughts and floods, and tropical cyclones. Its agricultural sector is the most exposed to these effects.

Ongoing climate disasters and climate change effects can set back project development gains, which means continuous support will be needed to adapt the sector and farmers to natural hazards. Since Vietnam is the world's largest exporter of rice and coffee, climate change implications may also spill over to global rice and coffee sectors through disruption of variability and supply, which in turn may affect global prices, farmer incomes, rural economic growth, and global consumption of rice and coffee. The external factor risks are therefore substantial.

109. It is very important to secure the Government's commitment to continue supporting the ARP, sustainable climate adaption, and low carbon transition, especially for the MKD. These will translate to plans to sustain and scale up the VnSAT results using the ODA and government funds. These commitments have been clearly reflected during the VnSAT closing workshop by MARD and provincial leaders and in the ongoing dialogue on supporting the proposed national 1 million-hectare high-quality low-carbon rice program, which is being developed by MARD with technical assistance from the World Bank.

110. As the Government introduced the Public Investment Law, which limits the use of ODA for 'soft' activities such as training and capacity building, there is a risk that any follow-up or new investment operation in the sector would fail to adopt best-practice technological solutions if they are offered without analytics and knowledge. At present, the Government requires the provinces to use their own budget or grant funds to finance training and capacity-building activities; hence there is a risk of insufficient budget allocated for these important activities in the future. The World Bank will need to continue to provide integrated and holistic engagements through a combination of lending, investment, analytical work, technical assistance, and policy dialogue.

111. FOs are key drivers of agricultural competitiveness and transformation, but they are still in the early development stage and need both financial and advisory support from the Government and international development partners. There is a risk that the continued training and concessional financing for FOs will no longer be possible using ODA funding. This will be a missed opportunity as FOs are on the front line of low-carbon transformation in Vietnam and will require technical assistance and financial support to promote and scale up CSA technologies successfully rolled out by the VnSAT.

V. LESSONS AND RECOMMENDATIONS

112. **The project was conceived and designed as a learning project and yielded important lessons relevant to agriculture sector transformation, which can be replicated within Vietnam and internationally.**

- **Linking a project to a national program** (that is, ARP in the VnSAT case). This will ensure that the project is well-aligned with the national priorities and receive strong ownership, commitment, and budget allocation. The VnSAT also acted as a catalyst for the development of the Government's renewed national low-carbon strategies, policies, and programs.
- **Providing a comprehensive package that is both 'climate and business smart'** can result in the high adoption of low-carbon cultivation technologies among farmers. On the one hand, the approach should be holistic by focusing on training, technical assistance, equipment/infrastructure, credit, policy, and regulation support. However, to scale up and roll out this CSA model, farmers should also understand its profitability. In the VnSAT case,

these included reduced production costs through the efficient use of inputs while maintaining (even increasing) production yield and quality.

- **Clustered development approach.** It is recommended to select the high potential and strategic crops (rice and coffee in the VnSAT case) and contiguous areas to develop GAP clusters/zones. These will improve efficiency and make it easier to connect with agribusiness and develop logistics for value chains.
- **Leveraging private sector financing.** Choosing a wholesale bank (BIDV) to oversee and coordinate the project credit line can help mobilize additional financial resources through private banks and end-borrowers. The wholesale banking model to support a credit component for the agricultural sector allowed to (a) attract many PFIs around the country, thus expanding access to finance for project beneficiaries in rural areas; (b) have an 'apex' institution that provided the Government and World Bank with timely advice regarding policy adjustments required to meet the needs of the market and banking sector; and (c) provide technical assistance to the PFIs (including training on World Bank safeguards policies). Most importantly, to increase the responsibility of PFIs and end-borrowers (rice enterprises and coffee farmers) as well as to ensure good-quality subprojects, the BIDV encouraged contribution funds from them, which, in turn, considerably increased the total investment under the credit line.
- **Institutional strengthening by linking fiscal performance, good policy-making, and human resources strengthening for better public service delivery**. The VnSAT successfully designed and implemented a well-aligned institutional strengthening component, whereby MARD and DARDs improved its fiscal performance (that is, quality and efficiency of budget planning and execution), complemented by improved enabling policies and targeted investment capacity strengthening of key agricultural service departments, all of which will have a lasting positive affect on sustaining the delivery of public services to farmers beyond the duration of the project.

ANNEX 1. RESULTS FRAMEWORK AND KEY OUTPUTS

A. RESULTS INDICATORS

A.1 PDO Indicators

Objective/Outcome: The PDO Indicators

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
PDO1. Number of project beneficiaries	Number	0.00 04-Nov-2014	800,000.00 09-Jun-2015		983,407.00 30-Jun-2022
Female beneficiaries	Percentage	0.00	50.00		50.00

Comments (achievements against targets):
Achieved 123% of the original target. The number of beneficiaries exceeded the project objective. Instead of provision of 3G3R training course for 6 days before 1M5R training, many provinces provided 1M5R training right away, thereby savings costs and increasing the number of participants.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
PDO2. Farming area under	Hectare(Ha)	0.00	150,000.00		184,643.00

sustainable farming practices: a) rice production		04-Nov-2014	09-Jun-2015		30-Jun-2022
b) Coffee production	Hectare(Ha)	0.00 04-Nov-2014	50,000.00 09-Jun-2015		70,446.00 30-Jun-2022

Comments (achievements against targets):
Achieved 123% of the planned target. The result has been mainly achieved through the effectiveness of training and extension activities.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
PDO3. Increase in net profits per hectare among targeted farmers: a) rice production	Percentage	0.00 04-Nov-2014	20.00 09-Jun-2015		31.60 30-Jun-2022
b) coffee production	Percentage	0.00 04-Nov-2014	20.00 09-Jun-2015		22.40 30-Jun-2022

Comments (achievements against targets):
Achieved 158% of the plan. The increase in profit is due to application of Good Agricultural Practices (GAP), which helped reduce the cost of seed production, fertilizers, and pesticides, reduce postharvest losses, and increase yield and price by about 5-10%.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion

PDO4. Reductions in GHG emissions from rice farming in the project area	Tons/year	0.00 04-Nov-2014	1,000,000.00 09-Jun-2015		1,582,299.00 30-Jun-2022

Comments (achievements against targets):
Achieved 158% of the planned target. This result is due to the application of alternate wetting and drying water management to reduce the number of inundation days, and application of GAP to reduce the consumption of inorganic fertilizers.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
PDO5. Improved quality of service delivery by MARD and DARDs in support of project implementation measured by performance scorecard: a) MARD (departments)	Number	0.00 04-Nov-2014	4.00 09-Jun-2015		4.00 30-Jun-2022
b) DARDs (provinces)	Number	0.00 04-Nov-2014	10.00 09-Jun-2015		10.00 31-May-2022

Comments (achievements against targets):
Achieved 100% of the plan. The participating Departments of MARD included the Department of Planning, Department of Plant Protection, Department of Crop Production and National Agricultural Extension Center.

A.2 Intermediate Results Indicators

Component: Component A: Institutional Strengthening to Support Agricultural Transformation

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
A.1: Improved performance in budget execution by MARD measured by a reduction in the discrepancy between budget allocations and end-of-year budget out-turns	Percentage	0.00 04-Nov-2014	20.00 09-Jun-2015		30.60 30-Jun-2022

Comments (achievements against targets):
Achieved 153% of the planned target.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
A.2: An MTEF covering MARD's investment and recurrent expenditure and MTEFs for DARDs	Number	0.00 04-Nov-2014	3.00 09-Jun-2015		3.00 30-Jun-2022

Comments (achievements against targets):
Achieved 100% of the planned target.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
A.3: Adoption of improved subsector ARPs in selected MARD departments (departments)	Number	0.00 04-Nov-2014	3.00 09-Jun-2015		7.00 30-Jun-2022

Comments (achievements against targets):
Achieved 233% of the planned target. The project invested in the development of the ARP and restructuring of 5 sub-sectors (including cultivation, husbandry, fisheries, forestry, agro-forestry-fishery processing,, and irrigation). The ARP Plan for 2017-2020 for MARD was approved by the Prime Minister in November 2017. In addition, the project also invested in the preparation of the ARPs for 7 pilot provinces including Vinh Phuc, Nam Dinh, Thanh Hoa, Ha Tinh, Binh Dinh, Lam Dong and Dong Thap.

Component: Component B: Supporting Sustainable Rice-Based Systems

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
B.1: Area of rice farming under sustainable farming practices as measured by reductions in pesticide and fertilizer use (ha)	Hectare(Ha)	0.00 04-Nov-2014	150,000.00 09-Jun-2015		208,951.00 30-Jun-2022

Comments (achievements against targets):

Achieved 153% of the planned target.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
B.2: Area of sustainable rice farming applying improved farming and post harvest packages to reduce water use and post harvest losses each by 30%	Hectare(Ha)	0.00 04-Nov-2014	75,000.00 09-Jun-2015		135,247.00 30-Jun-2022

Comments (achievements against targets):
Achieved 180% of the planned target.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
B.3: Area of sustainable rice farming under contract farming arrangements with agribusinesses	Hectare(Ha)	0.00 04-Nov-2014	50,000.00 09-Jun-2015		74,234.00 30-Jun-2022

Comments (achievements against targets):
Achieved 148% of the planned target.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
B.4: Investments by project-supported agribusinesses in additional milling/ processing capacity	Amount(USD)	0.00 04-Nov-2014	40,000,000.00 09-Jun-2015		97,310,000.00 30-Jun-2022

Comments (achievements against targets):
Achieved 243% of the planned target. The total amount of US$97.31 million of investments include US$33.27 million provided by the project Credit Line; US$61.93 million mobilized by the PFIs/end borrowers; and US$2.11 million of the Revolving Fund.

Component: Component C: Supporting Sustainable Coffee Production and Rejuvenation

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
C.1: Coffee area adopting sustainable farming practices as measured by reductions in presticide and fertilizer use: (a) Existing Plantations	Hectare(Ha)	0.00 04-Nov-2014	40,000.00 09-Jun-2015		53,200.00 30-Jun-2022
(b) Rejuvenation	Hectare(Ha)	0.00 04-Nov-2014	10,000.00 09-Jun-2015		18,283.00 30-Jun-2022

Comments (achievements against targets):
Achieved 133% of the planned target.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
C.2: Coffee area adopting advanced water saving irrigation technologies and reduce water use by at least 20% in the project areas	Hectare(Ha)	0.00 04-Nov-2014	22,000.00 09-Jun-2015		57,868.00 30-Jun-2022

Comments (achievements against targets):
Achieved 263% of the planned target.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
C.3: Area replanted with certified planting materials in the project areas	Hectare(Ha)	0.00 04-Nov-2014	7,000.00 09-Jun-2015		22,271.00 30-Jun-2022

Comments (achievements against targets):
Achieved 318% of the planned target.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
C.4: Number of pilot coffee-based landscape management plans developed in project areas	Number	0.00 04-Nov-2014	5.00 09-Jun-2015		5.00 30-Jun-2022

Comments (achievements against targets):
Achieved 100% of the planned target.

Component: Component D: Project Management

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Farmers reached with agricultural assets or services	Number	0.00 04-Nov-2014	170,000.00 09-Jun-2015		491,650.00 30-Jun-2022
Farmers reached with agricultural assets or services - Female	Number	0.00	40,000.00		245,825.00

Comments (achievements against targets):
Considerably exceeded the planned target. The total number of households using agricultural services is 245,825, including 178,370 rice-growing households and 67,482 coffee-growing households (2 farmers/households on average).

B. KEY OUTPUTS BY COMPONENT

Objective/Outcome 1: The use of improved farming practices in rice and coffee production in targeted provinces	
Outcome Indicators	1. Number of Project Beneficiaries 2. Farming area under sustainable farming practices (a) Rice production (ha); (b) Coffee production both existing plantations and rejuvenation (ha). 3. Reductions in GHG emissions from rice farming in the project area (tons).
Intermediate Results Indicators	1. Number of people trained 2. Area of rice farming under sustainable farming practices as measured by reductions in pesticide and fertilizer use (ha) 3. Coffee area adopting sustainable farming practices as measured by reductions in pesticide and fertilizer use (ha): (a) Existing plantations (ha) (b) Rejuvenation (ha) 4. Coffee area adopting advanced water saving irrigation technologies and reduce water use by at least 20% in the project areas (ha) 5. Area replanted with certified planting materials in the project areas (ha). 6. Reduced GHG emissions 7. Pilot coffee-based landscape management plans prepared 8. Farm household with access to agricultural assets and services
Key Outputs by Component (linked to the achievement of the Objective/Outcome 2)	1. The project reached out to 983,407 beneficiaries, 50% of them were women. 2. Total of 183,643 ha of rice production area is under sustainable farming practices. 3. Total of 208,951 ha of rice area that applied 2 criteria correctly; and total of 135,247 ha that applied 4 criteria correctly. 4. Existing coffee plantations: Total of 53,200 ha of existing coffee plantations is under sustainable farming practices; and 18,238 ha is rejuvenated. 5. The coffee area of 57,868 ha applied advanced water-saving irrigation technologies and reduced irrigation water. 6. The rejuvenated coffee area of 22,271 ha used certified seedlings. 7. GHG emissions reduced by 1,582,299 tons. 8. 491,650 households received agricultural assets or services.
Objective/Outcome 2: Improved rice and coffee value chains	
Outcome Indicators	1. Increase in net profits per hectare among targeted farmers in (a) Rice production (%) (b) Coffee production (%)

Intermediate Results Indicators	1. Area of sustainable rice farming applying improved farming and postharvest packages to reduce 30% water use and postharvest losses (ha) 2. Area of sustainable rice farming under contract farming arrangements with agribusinesses (ha) 3. Investments by project-supported agribusinesses in additional milling/ processing capacity (US$)
Key Outputs by Component (linked to the achievement of the Objective/Outcome 2)	1. Rice component: Average profit per ha increased by 32% among targeted farmers. 2. Coffee component: Average profit per ha increased by 22.4% among targeted farmers. 3. In the winter-spring crop 2021-2022, 74,234 ha of rice were under contract farming arrangements. 4. Total of US$97,31 million (US$33,27 from the project credit line; US$61.93 million from PFIs and end-borrowers; and US$2.11 from the Revolving Fund) was invested in additional milling/processing capacity. 5. Total of 135,247 ha of sustainable rice farming applied farming and post-harvest packages to reduce 30% water use and post-harvest losses.
Objective/Outcome 3: Public agencies strengthened to effectively support implementation of the Agricultural Restructuring Plan	
Outcome Indicators	1. Improved quality of service delivery by MARD and DARDs in support of project implementation as measured by performance scorecard for: (a) MARD (departments); and (b) DARDs (provinces).
Intermediate Results Indicators	1. Improved performance in budget execution by MARD measured by a reduction in the discrepancy between budget allocations and end-of-year budget out-turns (%) 2. An MTEF covering MARD's investment and recurrent expenditure and MTEFs for DARDs 3. Adoption of improved subsector ARPs in select MARD departments (departments) 4. Number of pilot coffee-based landscape management plans developed in project areas (plan)
Key Outputs by Component (linked to the achievement of the Objective/Outcome 2)	1. 4 Units in MARD and 10 selected provinces improved the quality of public service compared to the baseline assessment in 2016–2017. 2. Budget execution by MARD measured by a reduction in the discrepancy between budget allocations and end-of-year budget out-turns improved by 30.6%. 3. The project supported a series of policy and strategy reviews, including policies on agricultural land, science and technology, credit and loans, the ongoing ARP with its six sub-sectors (that is, Fisheries, Forestry, Water, Crop Production, Livestock Production, Agro-processing, and Market Development), the National Food Security Scheme, the Strategy for Livestock Development, and helped with the communication planning for the 2016-2020 ARP. 4. The project has supported MARD to develop its human resources by financing the organization of 45 conferences, workshops, and training courses for national and provincial officials to consult about the development/dissemination of policies and legal documents in the context of the ARP.

	5. Based on the borrower's separate report on completion of Component A, in total, 33 training courses for about 1,800 participants were delivered. Post-training evaluations survey of participants indicated that about 90% of the participants were satisfied with quality and relevance of the training events. 6. In collaboration with BIDV, the project has improved the credit and financial management capacity of 188 credit officers at partnering retail banks in the project target regions. Advanced know-how about BIDV credit procedures and processes helped to roll out the VnSAT line of credit component thus reaching 10 rice processors and 4,502 coffee farmers. 7. 5 coffee-based landscape management plans prepared.

ANNEX 2. BANK LENDING AND IMPLEMENTATION SUPPORT/SUPERVISION

A. TASK TEAM MEMBERS

Name	Role
Preparation	
Christopher Paul Jackson, Binh Thang Cao	Task Team Leaders
Thang Toan Le	Procurement Specialist
Ha Thuy Tran	Financial Management Specialist
Thu Thi Le Nguyen	Social Specialist
Nghi Quy Nguyen	Social Specialist
Supervision/ICR	
Hardwick Tchale, Binh Thang Cao	Task Team Leaders
Thang Toan Le	Procurement Specialist
Ha Thuy Tran	Financial Management Specialist
Thu Thi Le Nguyen	Environmental Specialist
Rahmoune Essalhi	Team Member
Hoa Thi Phuong Kieu	Procurement Team
Viet Quoc Trieu	Team Member
Nga Thuy Thi Nguyen	Procurement Team
Quynh Thuy Ngo	Social Specialist
David Jorge Baringo Ezquerra	Social Specialist

B. STAFF TIME AND COST

Stage of Project Cycle	Staff Time and Cost	
	No. of staff weeks	US$ (including travel and consultant costs)
Preparation		
FY13	4.225	41,534.44
FY14	38.423	237,810.39
FY15	53.444	274,274.49
FY16	9.325	42,478.61
FY17	0	1,140.49
Total	**105.42**	**597,238.42**
Supervision/ICR		
FY15	3.000	14,497.32
FY16	30.449	125,768.31
FY17	27.597	114,779.51
FY18	12.200	101,505.57
FY19	20.959	207,789.75
FY20	26.420	172,032.63
FY21	24.100	168,325.72
FY22	51.022	709,244.09
FY23	23.335	161,476.94
Total	**219.08**	**1,775,419.84**

ANNEX 3. PROJECT COST BY COMPONENT

Components	Amount at Approval (US$, millions)	Actual at Project Closing (US$, millions)	Percentage of Approval
Component A: Institutional Strengthening to Support Agricultural Transformation	5.00	1.74	35
Component B: Supporting Sustainable Rice-Based Systems	140.40	96.43	69
Component C: Supporting Sustainable Coffee Production and Rejuvenation	83.00	107.22	129
Component D: Project Management	9.60	5.95	62
Total	**238.00**	**211.34**[29]	**89**

[29] The difference between the amount of US$211.75 million reported in the datasheet and US$211.34 million indicated in this table is due to exchange rates used in the CPMU's project accounting system that are slightly different from those in the Bank's client connection

ANNEX 4. EFFICIENCY ANALYSIS

Introduction

1. Vietnam Sustainable Agriculture Transformation Project (VnSAT) was co-funded by the International Development Association (IDA) and the Government of Vietnam (GoV) through an agreement signed on July 9, 2015. The project became effective on December 3, 2015. The total project's original cost was US$314 million, of which US$238 million was from the IDA Credit, US$12 million from the Government funds, and US$64 million from local contributions. By project closing, the actual project disbursement was US$376 million, of which US$211.7 million[30] was from the IDA Credit, US$29.2 million from the Government funds, and USD 135.7 million from the private sector's contributions. The project implementation period was from 2015 to 2020. The non-credit Component was extended 18 months until June 2022.

2. The PDO was to contribute to implementing ARP by strengthening the institutional capacity of the sector, renovating sustainable farming practices, and enhancing the value chains for rice and coffee sectors in two key production areas of Vietnam: MKD and the Central Highlands. There were four project components:

- Component A: Institutional Strengthening to Support Agricultural Transformation
- Component B: Supporting Sustainable Rice Production
- Component C: Supporting Sustainable Coffee Production
- Component D: Project Management

3. For the rice component (Component B), the project aimed to support about 140,000 farm households with 200,000 ha of paddy land to adopt advanced farming techniques, helping to increase profit per ha by 30 percent and added value of the whole region by US$40–60 million per year. For the coffee component (Component C), the project aimed to support about 63,000 farm households with 69,000 ha of coffee land to adopt sustainable farming with advanced techniques, helping to increase profit per ha by 20 percent. This profit will last throughout the coffee business cycle (20–25 years). For both components, negative environmental impacts were reduced through the reduced use of water, fertilizers, and pesticides in rice and coffee production.

4. The project was implemented in 13 provinces and cities: An Giang, Can Tho, Dong Thap, Hau Giang, Kien Giang, Long An, Soc Trang, and Tien Giang in the MKD under the rice component and Dak Lak, Dak Nong, Gia Lai, Kon Tum, and Lam Dong in the Central Highlands under the coffee component. Apart from these, seven provinces, Vinh Phuc, Nam Dinh, Thanh Hoa, Ha Tinh, Binh Dinh, Dong Thap, and Lam Dong, also participated in implementing Component A for demonstration.

5. In September 2022, a final cost-benefit analysis of the project was undertaken to assess the economic impact of the project's interventions on the area of influence of the project. The analysis was based on the observed quantifiable benefits at the level of the primary beneficiaries associated with the

[30] Data from the Bank's Client Connection.

production of rice and coffee, considering project costs and completed works by June 2022. It should be emphasized that numerous potential project benefits have not been included in the analysis, as some benefits cannot be easily quantified in monetary terms, particularly institutional and some environmental benefits as well as the impact on other associated value chain actors that are not directly supported by the project. The findings of the analysis are summarized in this annex.

Expected Development Impact and Project Benefits

6. **Project area.** The VnSAT project's area of influence was where interventions to increase agricultural productivity and diversification were distributed across the 13 provinces of the project in the MKD and the Central Highlands. By June 2022, the area of rice farming under sustainable farming practices was 184,643 ha, representing an increase of 23 percent above the target of 150,000 ha. The coffee production area was 70,446 ha, which represented an increase of 41 percent above the target of 50,000 ha.

7. **Beneficiaries.** The total number of direct beneficiaries of the project was estimated at 983,407 people, which was 23 percent above the targeted 800,000 beneficiaries. Of these, there were 713,480 in the MKD provinces and 269,927 in the Central Highlands provinces. An estimated 50 percent of beneficiaries were female.

8. **Project component results.** Under Component A, the final assessment results showed that all four agencies in MARD and all 10 selected provinces had improved public service quality significantly compared to the first assessment (2016–2017). Three MTEFs for recurrent and investment expenditures have been developed (the end target is three MTEFs). Seven subsector ARPs have been reviewed (the target is three plans). The gap between the actual spending and the budget plan in 2021 was reduced by 30.6 percent, compared to the target of 20 percent.

9. Under Component B, the adoption of sustainable rice cultivation under the 3R3G process reached 184,643 ha (23 percent above the target of 150,000 ha) and under the 1M5R process reached 121,508 ha (62 percent above the target of 75,000 ha). The profit of farmers participating in the project increased by 31.6 percent compared to farmers outside the project (34.2 percent higher than before the project, the end target was 20 percent). The rice area under contract with enterprises in the Winter-Spring crop 2020–2021 was 74,234 ha (48 percent above the target of 50,000 ha). A total of 91 subprojects to support FOs/cooperatives with essential equipment and infrastructure and 86 public investment subprojects in the extension period supporting broader farming communities were completed and put into use before the project closure.

10. Under Component C, the area of coffee cultivation practice under the sustainable coffee production process was 52,162 ha (30 percent above the end-of-term target of 40,000 ha), and sustainable coffee rejuvenation was 18,283 ha (83 percent above the end-of-term target of 10,000 ha). The profit increase for farmers was 22.4 percent (12 percent above the target of 20 percent). The profit was 25.4 percent higher than before the project. A total of 42 sub-projects to support FOs and cooperatives with essential equipment and infrastructure and 29 public investment sub-projects in the extension period supporting broader farming communities were completed and put into use before the project closure.

11. Under Components B and C, a credit facility was implemented by the BIDV through credit lending activities. All funds allocated to this component (US$105 million) were disbursed. Particularly, the IDA disbursement of 10 rice mills reached US$33.27 million[31], while IDA disbursement for 4,502 coffee growers reached US$71.73 million in 9,700 ha of replanted coffee orchards[32]. After fully disbursing the balance from the Designated Account, the BIDV has continued to operate the Revolving Fund established by loan recoveries. As of June 2022, the cumulative disbursement from the Revolving Fund was around US$19.5 million, of which US$2.1 million was for rice mills, and US$17.4 million was for coffee rejuvenation.

12. **Benefits.** The project's benefits include both quantifiable and non-quantifiable benefits. Table 4.1 summarizes the benefits of the different components and whether they have been quantified in the EFA of the project.

Table 4.1. Benefits from Project Interventions and Their Quantification

Component	Benefits	Quantified in EFA (Yes/No)
A. Institutional Strengthening to Support Agricultural Transformation	• Improved public service quality significantly	No
	• Improved performance in budget execution by MARD	No
B. Sustainable Rice Production	• Increased productivity and profitability resulting from resource efficiency use	Yes
	• Reduced negative environmental impacts on water and soil from crop production	No
	• Reduced GHG emissions from rice farming in the project area	Yes
C. Sustainable Coffee Production	• Increased productivity and profitability resulting from resource efficiency use	Yes
	• Increased productivity and profitability resulting from improved infrastructure	Yes
	• Increased irrigated land value	Yes/No
	• Reduced climate vulnerability to droughts through irrigation use	Yes/No
	• Reduced negative environmental impacts on water and soil from crop production	No

Source: Project team's elaboration.

13. The major sources of quantifiable agriculture benefits were due to the project's interventions and by improving resource use efficiency (water, fertilizer, seed, and so on) under the 3R3G and 1M5R processes.

14. **Benefits not quantified.** The benefits that were not fully quantified or included in the EFA included the following:

(a) Improved public service quality

[31] The additional loans from the PFIs and the contributions from the agribusinesses to finance the remaining parts of their investment plans were US$61,93 million.
[32] The contributions from coffee farmers in their investment plans were around US$48,85 million.

(b) Improved performance in budget execution by MARD

(c) Reduction in the vulnerability to climate variability and change due to expansion of irrigation (coffee) and efficiency in water and fertilizer use (rice and coffee)

(d) Increased land value due to the expansion of irrigation in coffee production

(e) Reduced negative environmental impacts on water and soil from crop production.

Economic and Financial Analysis

15. **Economic costs and assumptions made.** According to the CPMU, the actual project disbursement was US$211.4 million from IDA Credit and US$29.3 million from government funds. The project cost and disbursement were disaggregated by year (2017–2022) and for each of the 13 provinces. The analysis was carried out for a 25-year period (2016–2041), which is the estimated project life, including the six years of project implementation. The economic analysis was undertaken in 2022 constant prices, and a discount rate of 10 percent was assumed in accordance with the World Bank project guidelines. The analysis focused on Components B (rice) and C (coffee). Thus, the costs of Components A and D were proportionally distributed to the cost of the rice and coffee components.

16. **Economic benefits.** In estimating the economic benefits, the analysis used the M&E information regarding changes in revenue and area adopting new sustainable practices for rice and coffee. The information for farm revenue was compared between the control and treatment groups to estimate the change in average revenue between the two groups (table 4.2). Table 4.3 shows the change in the project area under sustainable production practices for rice and coffee. Data from tables 4.3 and 4.4 were used to estimate the incremental increase in net profits in each province during the project implementation period (2017–2022). For the period beyond 2022, it was assumed that the revenue and area were constant at the values achieved in 2022.

Table 4.2. Average Net Revenue Change between Control and Treatment per Year (US$ per ha)

Province	2017	2018	2019	2020	2021	2022
Rice						
An Giang	258	258	160	187	268	256
Can Tho	201	201	64	141	317	271
Dong Thap	152	152	107	171	307	220
Hau Giang	141	141	166	204	347	493
Kien Giang	156	156	127	212	335	250
Long An	100	100	149	211	334	248
Soc Trang	177	177	150	202	225	225
Tien Giang	115	115	195	279	530	495
Coffee						
Dak Lak	105	105	201	272	370	434
Dak Nong	101	101	231	232	309	406
Gia Lai	116	116	227	311	385	547
Kon Tum	141	141	174	237	425	606
Lam Dong	117	117	296	390	519	920

Source: Project M&E data on average net revenue values (in VND, thousands) from control and treatment groups.

Table 4.3. Project Area under Rice and Coffee Production (ha)

Province	2017	2018	2019	2020	2021	2022
Rice						
An Giang	6,550	8,976	14,897	19,931	20,969	22,166
Can Tho	5,231	12,980	16,586	20,287	26,997	28,142
Dong Thap	10,318	10,961	22,317	24,408	24,232	25,079
Hau Giang	1,065	11,030	16,497	17,910	18,677	20,596
Kien Giang	3,597	13,852	19,553	23,495	24,394	25,222
Long An	263	3,479	13,840	20,128	22,220	25,206
Soc Trang	5,571	11,232	12,975	20,051	20,106	20,106
Tien Giang	7,843	12,257	13,526	17,207	17,847	18,126
Coffee						
Dak Lak	2,218	5,838	11,346	17,869	21,083	23,073
Dak Nong	1,233	3,857	9,908	16,719	17,455	17,957
Gia Lai	2,132	4,989	7,965	9,231	9,773	10,327
Kon Tum	700	963	2,069	2,809	2,965	3,315
Lam Dong	3,237	6,168	8,836	12,613	14,854	15,775

Source: Project M&E data.

17. **Rice mill investments.** Regarding the rice mills investments, the project included the EFA for those investments, allocating the net cash flow proportionally according to the total investment by province, as follows: An Giang (62.7 percent), Can Tho (22.9 percent), Dong Thap (4.9 percent), Kien Giang (7.7 percent), and Tien Giang (1.8 percent).

18. **GHG emission reductions.** Table 4.4 shows the estimated GHG emission reduction (tons per year) as a result of the best production practices in rice. The economic benefits of the emissions reduction were monetized following the World Bank methodology, using a low (US$40) and a high (US$80) carbon price, assuming an increase in the carbon price of 2.25 percent between 2021 and 2041.

Table 4.4. Reduction in GHG Emissions in the Project Rice Areas (tons/year)

Province	2017	2018	2019	2020	2021	2022
An Giang	19,613	45,725	84,763	204,565	222,048	235,626
Can Tho	22,973	81,159	49,500	144,109	222,012	230,261
Dong Thap	33,009	120,514	47,470	180,852	206,923	211,344
Hau Giang	2,831	50,295	18,870	159,293	166,249	176,228
Kien Giang	15,920	48,008	117,861	149,324	166,474	174,195
Long An	2,037	15,091	141,267	181,773	216,954	261,560
Soc Trang	15,839	40,972	90,988	140,552	170,722	170,722
Tien Giang	15,390	57,827	57,124	108,336	121,255	122,364

Source: Project M&E data.

19. **Economic viability and sensitivity analysis.** The analysis results are presented with and without the inclusion of the rice mill investments to isolate the impact of those investments and allow the project to present the net effects of the 3R3G and 1M5R processes.

20. Table 4.5 and figure 4.1 showed that the overall project's EIRR was 27.9 percent without the rice mill investments and 28.3 percent with the rice investments. This change was because the rice mill

investment EIRR was 30 percent, which increases slightly the overall project EIRR. The project's FIRR was 25.8 percent, and the FIRR for the rice mill investments was 17 percent. The NPV, discounted at 10 percent, for the project without rice mill investments was US$318 million, and with the rice mill investments was US$426 million. That is, although the rice mill investments had a lower IRR, the NPV was much higher, increasing the project's overall NPV. The benefit-cost ratio, estimated as the NPV of benefits divided by the NPV of project costs, was 4.5.

21. The results by project component showed that the IRR was 38.5 percent for rice and 19.7 percent for coffee. The IRR for the rice component was reduced to 35.5 percent once rice mill investments were accounted for. That is, the GAP rice investments (3R3G and 1M5R processes) had a relatively higher return than the rice mill investments (IRR of 30 percent). The results by region showed that there were differences among them, and there was no specific pattern. Of those provinces under the rice component, the IRR ranged from 10 percent to 122 percent, as follows: An Giang (62 percent), Can Tho (57 percent), Dong Thap (122 percent), Hau Giang (59 percent), Kien Giang (43 percent), Long An (48 percent), Soc Trang (10 percent), and Tien Giang (40 percent). These IRRs decreased for those provinces with rice mill investments as follows (for other provinces, remain the same): An Giang (34 percent), Can Tho (40 percent), Dong Thap (96 percent), Kien Giang (40 percent), and Tien Giang (39 percent). It is worth noting that the NPV for those provinces with rice mill investments increased substantially (An Giang, Can Tho, Dong Thap, Kien Giang, and Tien Giang, reflecting the increase in more than US$100 million in the project's NPV. The benefit-cost ratio ranged from 10.6 (Hau Giang) to 1.3 (Soc Trang).

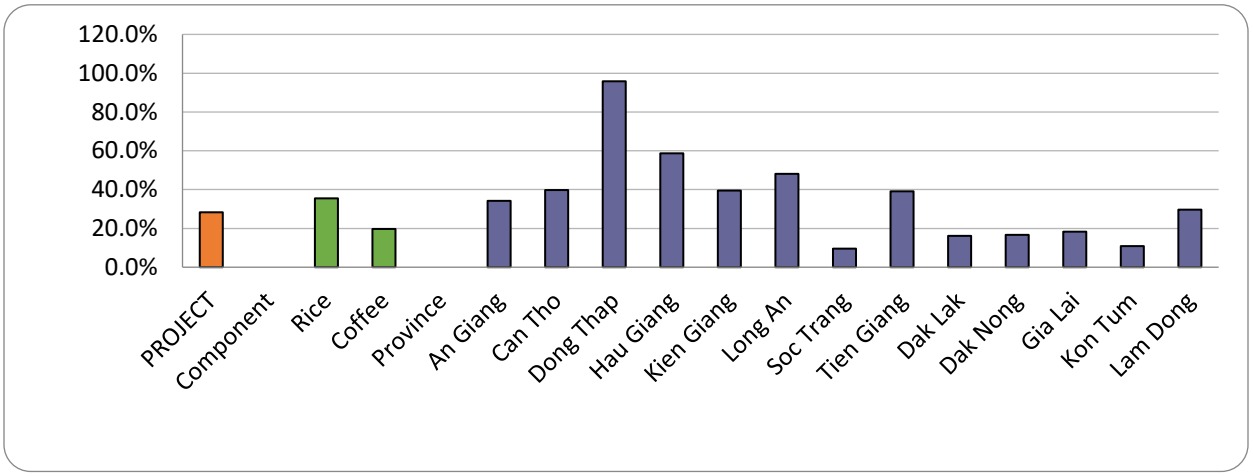
22. For the Highland provinces for coffee cultivation, the IRR ranged between 11 percent and 30 percent. The province with the highest IRR was Land Dong (30 percent). Dak Lak (16 percent), Dak Nong (17 percent), and Gia Lai (18 percent) had similar IRRs. Only Kon Tum had a lower IRR of 11 percent. The benefit-cost ratio for those provinces ranged between 6.4 (Lam Dong) and 1.6 (Kon Tum).

Table 4.5. Project Economic Analysis - IRR and NPV by Component and Province

	EIRR (%)		FIRR (%)	NPV (millions, US$)		Benefit-Cost Ratio	
	w/o Rice Mills	w/ Rice Mills	w/ Rice Mills	w/o Rice Mills	w/ Rice Mills	w/o Rice Mills	w/ Rice Mills
Project	27.9	28.3	25.8	318.2	426.2	4.5	6.1
By Component							
Rice	38.5	35.5	31.2	221.6	329.7	5.6	8.8
Coffee	19.7	19.7	19.7	96.6	96.6	3.4	3.4
By Province							
An Giang	62	34	23	24.8	92.5	5.8	25.2
Can Tho	57	40	32	32.0	56.7	6.3	12.2
Dong Thap	122	96	93	27.5	32.8	6.9	8.7
Hau Giang	59	59	59	45.6	35.1	10.6	10.6
Kien Giang	43	40	36	26.8	35.1	5.6	7.7
Long An	48	48	48	28.0	28.0	7.6	7.6
Soc Trang	10	10	10	-0.8	-0.8	1.3	1.3
Tien Giang	40	39	39	37.6	39.6	6.8	7.3
Dak Lak	16	16	16	18.3	18.3	2.6	2.6

	EIRR (%)		FIRR (%)	NPV (millions, US$)		Benefit-Cost Ratio	
	w/o Rice Mills	w/ Rice Mills	w/ Rice Mills	w/o Rice Mills	w/ Rice Mills	w/o Rice Mills	w/ Rice Mills
Dak Nong	17	17	17	13.7	13.7	2.6	2.6
Gia Lai	18	18	18	12.5	12.5	3.0	3.0
Kon Tum	11	11	11	0.6	0.6	1.6	1.6
Lam Dong	30	30	30	51.4	51.4	6.4	6.4

Figure 4.1. Project IRR by Component and by Province (%)



Source: Analysis based on the Project M&E data.

23. **GHG emissions economic benefits.** The previous analysis does not account for the monetization of the GHG emission reductions as a result of best practices in rice production that reduces GHG emissions. For this analysis, only the scenario without rice mill investments is considered, as they do not relate to the changes in rice practices. As the benefits are only accounted for under the rice component, the analysis is only for those provinces that are part of that component.

24. The results showed that when the monetized benefits of GHG emissions reductions in rice production were included, the overall project IRR increased to 57 percent under a low carbon price scenario and 96 percent under a high carbon price scenario. The NPV increased to US$736.8 million (low price) and US$1,154.4 million (high price). For the rice component, the EIRR was 120 percent assessed at a low carbon price and 231 percent at a high carbon price. The NPV increased from US$426 million under the standard scenario to US$640.2 million under a low carbon price, up to US$1,058.8 under a high carbon price.

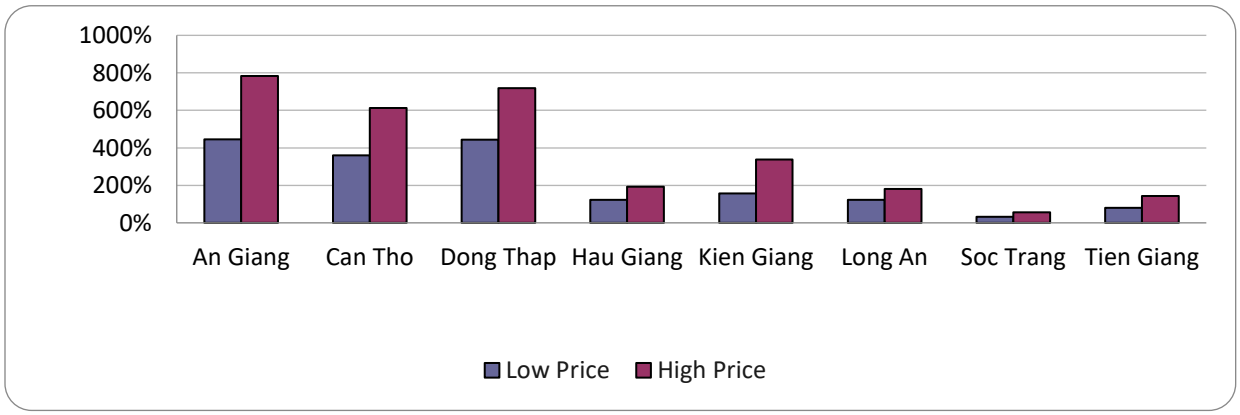
25. At the provincial level, the IRR also increased substantially, especially in some provinces, where the IRR surpasses 100 percent (An Giang, Can Tho, Dong Thap, Kien Giang, and Long An). The other three provinces showed an IRR ranging between 85 percent and 90 percent. The most significant gains in NPV corresponded to Long An, An Giang, Can Tho, and Dong Thap, adding to almost 60 percent of the total change in NPV.

Table 4.5. Carbon Economic Benefits - EIRR and NPV (US$, millions) by Component and Province

	EIRR (%)		NPV (USD million)	
	Low Price	High Price	Low Price	High Price
Project	57	96	736.8	1,155.4
By Component				
Rice	120	231	640.2	1,058.8
By Province				
An Giang	445	784	86.7	148.6
Can Tho	360	612	91.6	151.1
Dong Thap	444	718	85.6	143.0
Hau Giang	123	192	90.9	136.3
Kien Giang	157	339	74.6	122.3
Long An	123	180	94.6	161.0
Soc Trang	31	56	45.1	91.1
Tien Giang	81	144	71.5	105.4

Source: Project-level data include the coffee component.

Figure 4.2. Project IRR for Low and High Carbon Prices by Province (%)



Source: Analysis based on the Project M&E data.

26. **Comparison between EFA at project appraisal and EFA at project closing.** Table 4.6 compares the EIRR between project appraisal and project closing. The rates were slightly higher at project closing for both rice and coffee components. The EFA at project closing relied on the M&E data, which included the comparison of the control and treatment farmer groups. The observed incremental net revenue captures several of the expected benefits at project appraisal, including reduced production costs (from reduced use of water and inputs), reduced losses during harvest, milling, and storage, and higher value addition resulting from higher quality and higher sale prices. For the rice mills, the analysis may capture the increased income from increased conversion from paddy to rice and higher selling price and value from higher quality rice. For coffee, the observed incremental net revenue captures several of the expected benefits at project appraisal, such as increased productivity and profitability resulting from sustainable agronomic and management practices, including water-saving technologies, increased prices

(due to improved quality), reduced post-harvest losses, and reduced transaction and input costs. It is worth noting that at project appraisal, reduced GHG emissions were not included in the EFA.

Table 4.6. Comparison of EIRR by Component between Project Appraisal and Closing (percentage)

Project / Component	Appraisal	Closing
Project	24	28
Component B1 (Rice)	32	36
Component B2 (Rice)	24	36
Component C (Coffee)	18	20

Note: Excluding GHG emission reduction benefits.

27. While the EFA at closing relied on the observed M&E data from the control and treatment farmer groups for both rice and coffee, the EFA at appraisal relied on the assumption of the intervention models from rice (six models, including 3R3G, 1M5R, and its different permutations regarding cooperative membership, use of combine harvester and drying/storage, and contract farming) assuming a reduction in production costs, increased prices, and reduced harvesting and post-harvest losses. Those assumptions are captured by the observed incremental net revenue in the current EFA. The same applies to coffee production models, including FFSs with improved agronomic practices only and the use of drip irrigation, replanting, and/or grafting in addition to the FFS.

ANNEX 5. BORROWER, CO-FINANCIER AND OTHER PARTNER/STAKEHOLDER COMMENTS

Ministry of Agriculture and Rural Development
International Cooperation Department

Thank you for sharing the VnSAT Project Completion Report implemented by the World Bank (WB). After studying the report, we have some comments as follows:

1. **Overall assessment**: Project completion report made by WB: (i) Basically, the contents and data mentioned in the report have no difference compared to the report provided by the Project ; (ii) Similar to the report provided by the Project, most of the evaluation indicators of the Project in the WB's report are satisfactory and exceed the proposed project objectives; (iii) Some contents in the WB's report were analyzed in more detail and logic, especially the PDO indicators. (iii) We agree that: (a) The VnSAT project completion report prepared by the WB has reflected most of the contents and results that the project has actually achieved.; (b) The evaluations and levels of evaluation of the criteria are consistent with those in the project completion report provided by the Project and agreed that PDO is rated **'High'**.

2. **Project's Results**: We highly appreciate the evaluation by WB that: (a) "At the time of preparation of this ICRR, the VnSAT has been already widely acknowledged as a best practice "green" agricultural transformation project and; (b) The project fully achieves its development objectives of improving: (i)) farming practices; (ii) value chains in the targeted project areas; and (ii) promoting institutional strengthening of relevant public agencies to effectively support implementation of the Agricultural Restructuring Plan. This is also the general assessment of MARD, Ministries, sectors, and units related to the project and the provinces participating in the project, especially farmers in the project area. This assessment will create an opportunity for Vietnam in general and the Mekong Delta in particular, request the WB to continue supporting the project on "carbon reduction and green growth".

3. **The WB's completion report assesses PDOs**: (i) The project has performed very well in PDO Part 1; Very well done in PDO Part 2; The good performance in PDO Part 3 is authentic and it also coincides with the assessment of the Ministry of Agriculture and Rural Development: "VnSAT is one of the most successful projects among the projects funded by the World Bank and supported by provinces, Units participating in the project, farmers' organizations highly appreciate it". These assessments show that the Project has contributed to: (i) Supporting the development, review, and revision of the Scheme on restructuring sectors and sub-sectors, a number of Laws, Decrees, and Cooperative Development Schemes approved by the National Assembly and the Government; (ii) Changing the behavior and awareness of rice and coffee producers according to the sustainable farming process, reflected in the increasing application area, helping farmers reduce input costs, improve the quality volume and added value; (iii) Support the establishment, consolidation, and improvement of activities of farmer cooperatives organizations, create favorable conditions for cooperation and association for sustainable product consumption (iv) Effective use of credits in the agricultural Project.

4. **The lessons learned**: The contents from the WB's implementation completion report are similar to those in the project completion report prepared by MARD. The project was conceived and designed as a learning project and yielded important lessons relevant to agriculture and sector transformation, which can be replicated within Vietnam and internationally". However, the specific lessons only give some main lessons: (i) Linking a project to a national program (i.e., ARP in the VnSAT case (ii) Clustered development approach; (iii) Providing a comprehensive package that is both "climate and business smart; (iv) Leveraging private sector financing; (v) Institutional strengthening We find these lessons applicable to

projects agriculture in Vietnam and in the World.

We would like to thank the World Bank for its effective support to the agricultural sector in general and the VnSAT project in particular and look forward to receiving the support in the near future.

ANNEX 6. SUPPORTING DOCUMENTS

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ANNEX 7. BENEFICIARY'S FEEDBACK

Le Minh Hoan, Minister of Agriculture and Development

The VnSAT project helps form the coffee industry in the Central Highlands so that we can go far in a more sustainable way. The Ministry of Agriculture and Rural Development (MARD) will continue to promote the effectiveness of the VnSAT and a number of other sustainable coffee development projects. MARD will also boost logistics activities for the Central Highlands' coffee industry to create more added value, with more sophisticated and superior products than in the past, from there, building a product chain to increase the value of coffee.

Le Quoc Doanh, Deputy Minister of Agriculture and Development

The VnSAT project has not only a meaningful effect on economic development such as increasing productivity and quality for the rice and coffee industries, but also improves and creates very positive changes for the environment and society. The World Bank regards VnSAT as a model project. Through the VnSAT project, we have also determined that the production of rice and coffee in particular and other agricultural commodities in general must always be towards a sustainable development goal. We should not only increase productivity but also reduce production costs from which there will be an impact to better protect the environment, especially help reduce the use of fertilizers and plant protection drugs.

Tran Thanh Nam, Deputy Minister of Agriculture and Rural Development

The results achieved by the VnSAT project have had a great effect on the coffee industry and the local agricultural economy. In the coming time, it is necessary to speed up the construction of standard sustainable raw material areas. To do this, it is necessary to build and develop community agricultural extension groups, communicate and develop raw material areas, support and consult for the development of cooperatives, connect markets with farmers, promote chain linkage between enterprises with cooperatives and farmers in producing, processing and consuming coffee.

Bui Ba Bong, Former Deputy Minister of Agriculture and Rural Development

Vietnam's experience in implementing the VnSAT Project for many years has created a very good premise for science and technology. The Project also has conducted many effective models, from small scale to large scale. Therefore, we can promote and multiply the building of large low-carbon rice fields. The goal is that we should build 600,000 ha of low carbon rice among 1 million ha of high-quality rice according to the target set by the MARD. MARD is proposed to launch a program on building large rice fields with low carbon emissions.

Nguyen Do Anh Tuan, General Director of International Cooperation Department, MARD

During its implementation, VnSAT Project has received a very specific and drastic leadership and direction of MARD and been under close coordination with localities, the business community, and cooperatives in coffee production in the Central Highlands and rice industry in the Mekong Delta. In particular, the project has helped change local farming behavior thereby, helped reduce input costs and improved the competitiveness of the agricultural industry. The VnSAT Project has made a great contribution to

supporting farmers, cooperatives and enterprises to create more standard and quality agricultural products and overcome technical barriers in importing countries.

Le Van Hien, Head of Management Board of Agricultural Projects

The policy of shifting from agricultural production to agricultural economic development to form an ecological agriculture, modern countryside and smart farmers requires the whole political system, especially the agricultural and rural development sector, farmers and farmer organizations, cooperatives, businesses and local authorities to change their old perception of thinking into a new and modern one so that to possess adequate standards meeting domestic and export market demands.

Box 7.1. Benefits of Adopting Improved Rice Farming Practices

Ms. Le Dong Phuong lives at D2 hamlet of Thanh Loi Commune, Vinh Thanh District of Can Tho City. Her family includes her husband, her two children, and herself. Her family has cultivated rice since 2005 and joined the VnSAT in 2016.

In 2010, income from 3 ha of rice cultivation was enough to cover the family's expenses; however, in the subsequent years, the income quickly declined due to increased fertilizers, pesticides, and other farm inputs. Before joining the VnSAT, rice income could cover only 70 percent of the family's living expenses; the remaining came from other sources, such as pig farming, chicken raising, and working as a hired laborer.

After receiving training from the VnSAT, she and other farmers in the cooperative reduced the rice seeding rate from 190 kg/ha to 100 kg/ha. At the lower density, rice grows very well, and yields are high, around 6.3–7 tons/ha, depending on the season. Owing to the reduced seeding rate, fertilizers and pesticides were also reduced. In addition, she also applied wetting and drying techniques, which helped reduce water pumping by around 40 percent. Adopting improved farming techniques has helped her reduce production costs by around 25 percent and increase farm profit by around 40 percent. The project also provided matching grants for the cooperative to construct a dryer and storage, which helped her family reduce post-harvest loss by around 15 percent. By linking with agribusinesses through contract farming, she feels more confident adopting the improved farming techniques recommended by the project.

Box 7.2: Project's Impact on Women

Ms. Nguyen Thi Thuy Trang lives at E1 hamlet of Thanh An Commune, Vinh Thanh District of Can Tho City. Her family has five members—her husband, three children, and herself—cultivating 1.5 ha of rice since 2002. She joined Hieu Binh Cooperative in 2014. Before joining the cooperative, she and other farmers took turns helping each other in land preparation, seed broadcasting, and harvesting due to the lack of labour. She and her husband had to work in the field from dawn to dark. The heavy fieldwork included rice broadcasting, water pumping, fertilization, harvesting, and paddy sun-drying. She did not have much time to prepare good meals for the family or care for her children.

Her Hieu Binh Cooperative joined the VnSAT in 2016. She and other farmers in the cooperative received training from the project in improved farming techniques to reduce production costs. In 2018, the cooperative received matching grants from the project to buy a transplanting machine, dryer, and storage and construct an electric pumping station. The cooperative also formed a technical group in charge of fertilization, spraying, and taking care of all heavy work for the members. Since the day the cooperative had the dryer, she was no longer worried about the rains during the harvesting period. This is particularly meaningful to her because this work used to be done by women. Now women in the cooperatives have more time to take care of their families better. Some joined women's self-help groups to help each other in economic activities. She learned tailoring and worked at

home to earn an additional income of about 3–4 million per month. Owing to having a higher income, her health was also getting better. Her livelihood was also getting more stable. She wished to thank the VnSAT.

ANNEX 8. METHODOLOGY FOR CALCULATION OF GHG EMISSION REDUCTION

1. The World Bank-financed ACP was implemented from 2008 to 2014. In October 2012, the project was restructured to include a pilot program to support sustainable rice farming and post-harvest management in seven provinces (Dong Thap, An Giang, Kien Giang, Long An, Tien Giang, Soc Trang, and Can Tho) in the MKD. 1M5R techniques were introduced to help farmers reduce economic and environmental costs and improve farming profits.

2. Under the ACP, field experiments were designed to compare GHG emissions between two farmer groups: the traditional farming practice group (control) and the one adopting 1M5R in Can Tho and Tien Giang provinces. Can Tho University has conducted GHG field measurements for three consecutive rice crops: Winter–Spring crop (November 2012–Mar 2013) and Summer–Autumn crop (April–July 2013), and Autumn-Winter crop (July–October 2013). The results showed that the application of 1M5R-AWD reduced CO_2e per ha per crop (58 percent) from 7.4 to 12.5 tons compared to the traditional group in the Winter-Spring crop (the dry season), from 5.4 to 6.4 tons of CO_2e per ha per crop in the Summer-Autumn crop (April–July 2013), and from 15 to 19 tons of CO_2e per ha per crop in the Autumn-Winter crop (July–October 2013) (reports attached). Total GHG emissions from the control group (traditional farming practices) averaged 41.5 tons of CO_2e per ha per year, while only 8.2 tons of CO_2e per ha per year from the 1M5R group.

3. The VnSAT was prepared from 2014 to 2015 and approved in July 2015. The project was implemented from July 2015 to June 2022. At appraisal, the results of GHG field measurements under the ACP (closed in June 2014) were used as the baseline data for the VnSAT.

4. Under the VnSAT, the Institute for Agricultural Environment (IAE) conducted GHG field measurements again. However, because the technical assistance team came on board late, field measurements under the VnSAT started late, from November 2019 to October 2020 (four years after implementation). Results showed that total GHG emissions of VnSAT's 1M5R group were 8.29 tons of CO_2e per ha per year, similar to that under the ACP (8.2 tons of CO_2e per ha per year). However, average GHG emissions from the traditional group under the VnSAT were only 10.8 tons of CO_2e per ha per year compared to 41.5 tons of CO_2e per ha per year under the ACP. There are several possible reasons for the differences. One could be that the 'control' group under the VnSAT had partially adopted 1M5R (GHG measurements under the VnSAT started late, four years after project implementation).

5. Looking ahead, defining the baseline data to measure GHG emission reduction for future low-carbon projects is challenging because it keeps changing due to the rapid increase in farmers' adoption of 1M5R when farmers have seen the benefits of the improved techniques from their neighbors.

GHG Measurement Methodology under the ACP (Extracted from the Can Tho University's Report, 2015)

1. Soil Data

Soil samples were taken by the Mekong Development Research Institute (MDI) staff and Lab of Can Tho University at the end of each crop. The consultants monitored the process of soil sampling methods.

2. GHG Data

GHG sampling was carried out by the team at the research sites, including the local technicians and MDI's staff, weekly for CH_4 and at fertilization time for N_2O. The consultants (Dr. Tran Kim Tinh, Huynh Quang Tin, and Nguyen Van Sanh) performed the technical monitoring and management of gas sampling.

3. Agronomic Data

Agronomic data were collected weekly by the MDI staff and agricultural extension workers with the selected farmers for on-farm research. The water level on the fields was recorded every day by participating farmers and checked and monitored by the consultants.

4. Socioeconomic Data

The consultants developed the dairy book records with the participation of farmers and agricultural extension workers. The participating farmers recorded the input costs of each household. Then, these records were checked seven times per crop by the MDI's staff and agricultural extension workers at the project sites.

5. Methodologies

a. **Methodology applied in the collection of soil data**

In random sampling, individual samples were collected from locations. A zigzag sampling pattern was used for field sampling. All samples were combined, and a composite sample was taken and submitted for laboratory analysis (Carter and Gregorich edited 2008).

b. Methodology applied in GHG emissions measurement

The United States Department of Agriculture GraceNet[33] protocol was used to establish the measurement procedure. A sampling chamber with a dimension of 70 cm in diameter and 100 cm in height was used to take gas samples. Two chambers were placed on fixed basement structures in each field, and gases were withdrawn with a syringe through a sample port at the top of the chamber at 0, 10, and 20 minutes. Gas samples were stored in evacuated vials for transport from the field to the Advance Lab. GHGs were measured on Gas Chromatographs at the Advanced Laboratory at Can Tho University. An electron capture

[33]http://www.ars.usda.gov/research/programs/programs.htm?np_code=212&docid=21223.

detector (ECD) was used for N_2O determination, and an flame ionization detector (FID) was used for CH_4 determination. More detailed descriptions are presented below:

Chamber Preparation

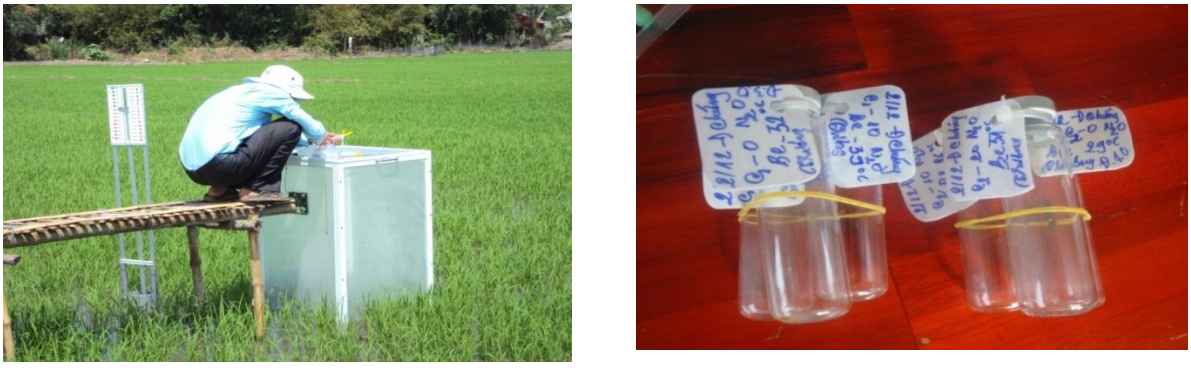
Chamber with a dimension of 60 x 80 x 100 cm was prepared. Air was mixed by a 12 V fan. The temperature was measured by a thermometer. Air was sampled by a syringe connected to a valve placed on top of the chamber.

Figure 8.1. Chamber and Basement Establishment at the Study Fields

Before sampling, a bridge was prepared. A basement was installed permanently on the field and kept for one crop. This basement was used to seal off the connection between the chamber and the mud surface during sampling. The chamber was installed in the basement, and the sampling process was started.

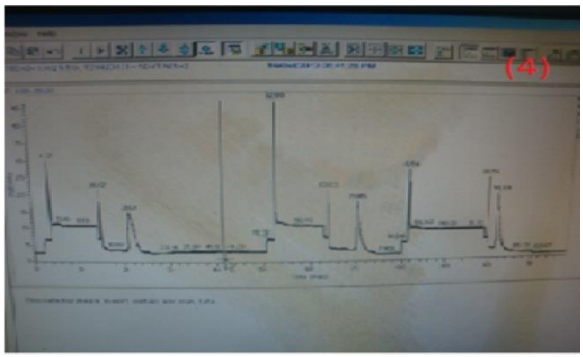
Sampling Processes

Figure 8.2. Sampling Gas and Evacuated Vials a Day Before Sampling



First a battery was attached to a wire connected to a fan inside the chamber. Then a syringe was attached to the sample port and purged with several volumes of chamber air to clean the syringe. A sample was drawn into the syringe, the stopcock was closed, and the syringe was removed from the sample port. A labeled evacuated vial is attached to the syringe needle. The sample was compressed into the vial, after which the stopcock was closed, and the needle was withdrawn.

Figure 8.3. Analyzing Gas Samples by GC 14B



Upon arrival, field samples were labeled and logged into the database as the first step in data quality control. The sample was injected into the sampling loop of the Gas Chromatograph by a peristaltic pump. Packed column was used with Porapak-Q material. The Gas Chromatograph used is Shimadzu GC 14B. CH_4 was detected by FID detector and N_2O was detected by ECD detector. CH_4 or N_2O signal was recorded by a data acquisition box (Agilent Model SS420X).

GHG flux was calculated with an equation:

Flux (mg CH4/m^2 × h) = SLOPE(C0, C1, C2/T0, T1, T2) × 60 / (A)

In which,

- **A is the soil surface area (m^2)**
- **C0, C1, and C2 are the chamber headspace gas concentrations (ppm(v)) at time 0, 10, and 20 minutes**
- **t_i is the interval between gas sampling points (min)**

c. Methodology used in collecting agronomic data

Plant height and number of tillers were measured and counted weekly at three located frames (50 cm x 50 cm) of each field. Grain yield was harvested at three plots (10 m^2) of each field. The weight of grains is weighted and converted to ton per ha.

d. Methodology used in collecting socioeconomic data

The MDI staff prepared the diary record and trained farmers to record input cost data. After training, each farmer was provided the diary record and filled up the data themselves. The MDI staff checked the diary record weekly to assist if having problems.

6. Materials and Equipment (used in the field and laboratory)

a. Soil Data (methods and equipment used for collecting soil data)

- Soil texture: By triangle method
- Clay content: By Robinson method

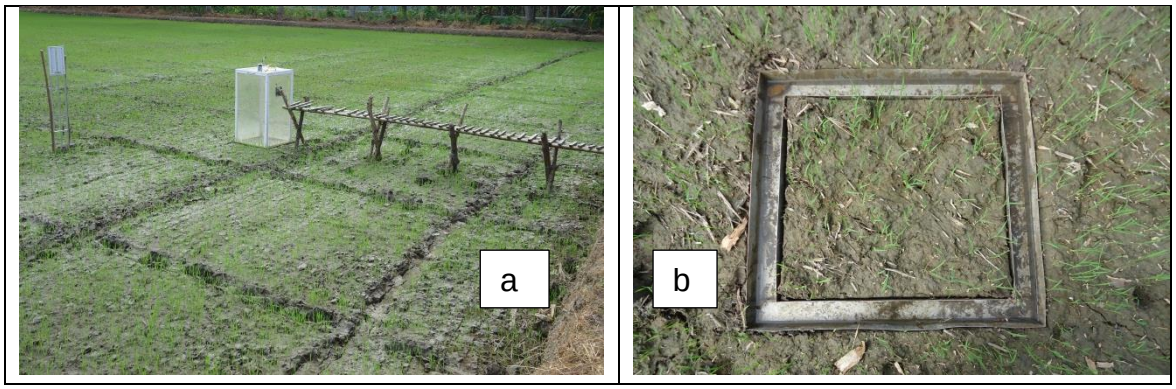
- Organic C: By Walkley-black method
- Total N: Kjeldahl method

Soil pH: extract soil: water ratio of 1:5
CEC: Unbuffer method, by titration

b. GHG measurement (field chambers dimensions, chamber set up, and laboratory equipment)

Figure 8.4 shows the design of the tools for GHG measurement on each field, including a bridge - 5 m long from field-dike; the basement was located at the end of the bridge; and the water monitoring tube was placed near the chamber.

Figure 8.4. Chamber and Bridge, Water Measuring Tool (a), Basement (b)



c. Agronomic data (methods and equipment used for collecting agronomic data)

Three frames (50 cm x 50 cm) were placed on each field to measure plant height and number of tillers. The location of frames is representative of the density of rice plants.

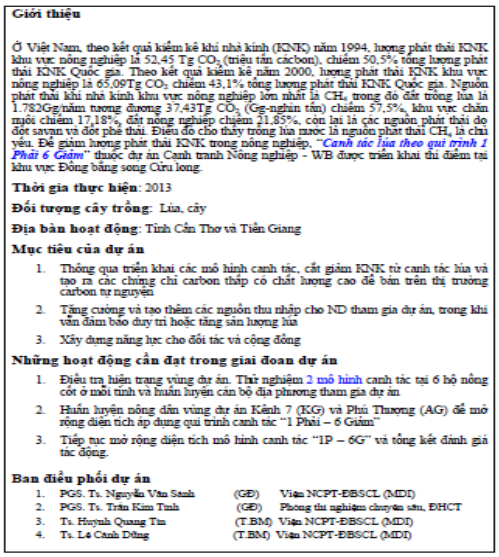
Figure 8.5. Location of Data Collection on Plant Height and Tillers

d. Socioeconomic data (methods used for collecting costs and revenue of crop production, and so on)

Diary records were the main method for economic data collection. It was designed to be simple and

easy for farmers to use.

Figure 8.6. Diary Records for Farmers' Use at the Households



Giới thiệu

Ở Việt Nam, theo kết quả kiểm kê khí nhà kính (KNK) năm 1994, lượng phát thải KNK khu vực nông nghiệp là 52,45 Tg CO_2 (triệu tấn cácbon), chiếm 50,5% tổng lượng phát thải KNK Quốc gia. Theo kết quả kiểm kê năm 2000, lượng phát thải KNK khu vực nông nghiệp là 65,09Tg CO_2 chiếm 43,1% tổng lượng phát thải KNK Quốc gia. Nguồn phát thải khí nhà kính khu vực nông nghiệp lớn nhất là CH_4 trong đó đất trồng lúa là 1.782Gg/năm tương đương 37,43Tg CO_2 (Gg-nghìn tấn) chiếm 57,5%, khu vực chăn nuôi chiếm 17,18%, đất nông nghiệp chiếm 21,85%, còn lại là các nguồn phát thải do đốt savan và đốt phế thải. Điều đó cho thấy trồng lúa nước là nguồn phát thải CH_4 là chủ yếu. Để giảm lượng phát thải KNK trong nông nghiệp, "*Canh tác lúa theo qui trình 1 Phải 6 Giảm*" thuộc dự án Canh tranh Nông nghiệp - WB được triển khai thí điểm tại khu vực Đồng bằng sông Cửu long.

Thời gia thực hiện: 2013

Đối tượng cây trồng: Lúa, cây

Địa bàn hoạt động: Tỉnh Cần Thơ và Tiền Giang

Mục tiêu của dự án

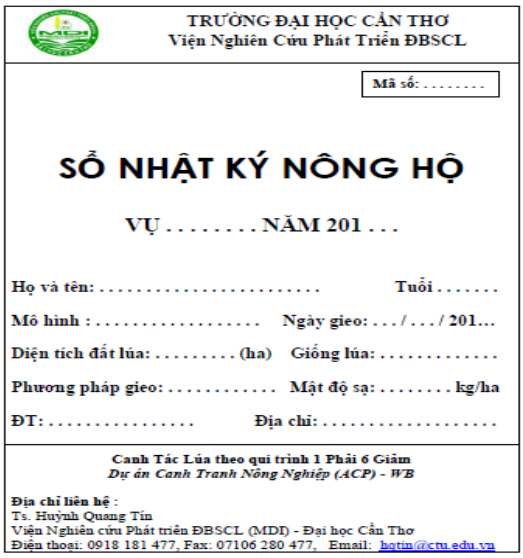
1. Thông qua triển khai các mô hình canh tác, cắt giảm KNK từ canh tác lúa và tạo ra các chứng chỉ carbon thấp có chất lượng cao để bán trên thị trường carbon tự nguyện
2. Tăng cường và tạo thêm các nguồn thu nhập cho ND tham gia dự án, trong khi vẫn đảm bảo duy trì hoặc tăng sản lượng lúa
3. Xây dựng năng lực cho đối tác và cộng đồng

Những hoạt động cần đạt trong giai đoạn dự án

1. Điều tra hiện trạng vùng dự án. Thử nghiệm 2 mô hình canh tác tại 6 hộ nông cốt ở mỗi tỉnh và huấn luyện cán bộ địa phương tham gia dự án
2. Huấn luyện nông dân vùng dự án Kênh 7 (KG) và Phú Thượng (AG) để mở rộng diện tích áp dụng qui trình canh tác "1 Phải – 6 Giảm"
3. Tiếp tục mở rộng diện tích mô hình canh tác "1P – 6G" và tổng kết đánh giá tác động.

Ban điều phối dự án

1. PGS. Ts. Nguyễn Văn Sánh (GĐ) Viện NCPT-ĐBSCL (MDI)
2. PGS. Ts. Trần Kim Tính (GĐ) Phòng thí nghiệm chuyên sâu, ĐHCT
3. Ts. Huỳnh Quang Tín (T.BM) Viện NCPT-ĐBSCL (MDI)
4. Ts. Lê Cảnh Dũng (T.BM) Viện NCPT-ĐBSCL (MDI)



TRƯỜNG ĐẠI HỌC CẦN THƠ
Viện Nghiên Cứu Phát Triển ĐBSCL

Mã số: .....

SỔ NHẬT KÝ NÔNG HỘ

VỤ ..... NĂM 201 ...

Họ và tên: ..... Tuổi .....

Mô hình : ..... Ngày gieo: .../.../201...

Diện tích đất lúa: ..... (ha) Giống lúa: .....

Phương pháp gieo: ..... Mật độ sạ: ..... kg/ha

ĐT: ..... Địa chỉ: .....

Canh Tác Lúa theo qui trình 1 Phải 6 Giảm
Dự án Canh Tranh Nông Nghiệp (ACP) - WB

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GHG Measurement Methodology under the VnSAT (Extracted from the IAE Report, 2020)

Gas monitoring and sampling are carried out in three rice crops cultivation areas: in Can Tho, Kien Giang and An Giang provinces and in two rice crops cultivation areas: in Long An, Soc Trang, Dong Thap, Hau Giang, and Tien Giang

In each province, choose three models with the scale of 0.5–1 ha per model. Only 2 models 1M5R and 3R3G must be confirmed by the PPMU, ensure the typicality of the project, and represent the ecological region.

Control Model (traditional farming model of the people being deployed outside the project area)

Each model has four monitoring points arranged in a large plot, with no replication. Each monitoring point in the model is considered as one replication.

➔ **Total number of monitoring points: 4 points × 3 model × 8 provinces = 96 points**

Table 8.1. List of GHGs Monitoring Locations

No.	Province	District	Commune	Hamlet	Model	Coordinates
1	Can Tho	Co Do	Trung Thanh	Thanh Loc	1M5D	10.17713°N; 105.52673°E
2		Co Do	Trung Thanh	Thanh Loc	3R3G	10.18048°N; 105.52335°E
3		Vinh Thanh	Thanh My	Dat Moi	Traditional	10.24353°N; 105.42544°E

No.	Province	District	Commune	Hamlet	Model	Coordinates
4	Soc Trang	My Xuyen	Thanh Quoi	Day So	1M5D	9.44902°N; 105.78366°E
5		My Tu	Phu My	Soc xoai	3R3G	9.54741°N; 105.8772°E
6		Thanh Tri	Thanh Tri	Truong Hien	Traditional	9.43870°N; 105.73545°E
7	Hau Giang	Long My	Xa Phien	4	1M5D	9.62185°N; 105.53878°E
8		Long My	Xa Phien	7	3R3G	9.61119°N; 105.52918°E
9		Long My	Xa Phien	4	Traditional	9.63336°N; 105.52619°E
10	Kien Giang	Chau Thanh	Mong Tho A	Thanh Hoa	1M5D	10.04103°N; 105.1547°E
11		Tan Hiep	Thanh Dong A	HTX Kenh 7b	3R3G	10.02013°N; 105.26606°E
12		Chau Thanh	Mong Tho A	Phuoc tan	Traditional	9.98133°N; 105.20988°E
13	An Giang	Thoai Son	Vinh Trach	Vinh Trung	1M5D	10.33218°N; 105.35429°E
14		Thoai Son	Vinh Trach	Vinh Trung	3R3G	10.33191°N; 105.35316°E
15		Thoai Son	Vinh Chanh		Traditional	10.322400°N; 105.368675°E
16	Dong Thap	Hong Ngu	Thuong Phuoc 1	3	1M5D	10.85613°N; 105.23747°E
17		Hong Ngu	Thuong La	thi	3R3G	10.82614°N; 105.29888°E
18		Hong Ngu	Thuong Thoi Hau B	6	Traditional	10.85359°N; 105.29212°E
19	Tien Giang	Cái Bè	Hậu Mỹ Bắc B	Hau Quo	1M5D	10.47232°N; 106.17347°E
20		TX Cai Lay	My Hanh Dong	My Luong	3R3G	10.51158°N; 105.97319°E
21		TX Cai Lay	Tan Phu	Bac	Traditional	10.43365°N; 106.18976°E
22	Long An	Moc Hoa	Binh Hoa Trung	HTX Huong Trang	1M5D	10.76781°N; 105.99819°E
23		Moc Hoa	Binh Hoa Trung	HTX Huong Trang	3R3G	10.7681984°N; 105.9955017°E
24		Moc Hoa	Tap Lap	4	Traditional	10.70672°N; 105.99633°E

✓ **Frequency and monitoring indicators:**

Sampling for analysis of methane gas (CH_4) at eight stages (based on the growth stage and water management regime) and the number of N_2O analysis samples were taken at six stages (based on the time of fertilization and drainage)

Table 8.2. Frequency and Number of GHG Samples Taken

No.	Growth Stage	Growth Time (Days After Sowing/Transplanting)	Number of GHGs Samples for CH_4 Analysis	Number of GHGs Samples for N_2O Analysis
1	Rooting	10–15 DAS	384	384
2	Tillering	20–30 DAS	384	384
3	Stem elongation	30–45 DAS	384	384
4	Booting/heading	45–55 DAS	384	384
5	Flowering	55–70 DAS	384	
6	Milk gain	70–85 DAS	384	384
7	Dough gain	80–95 DAS	384	384
8	Mature gain	90–100 DAS	384	

Monitoring changes in soil and water environment: water level depth, air temperature, before each gas measurement.

✓ **Number of samples taken:**

+ Total gas samples taken: 7.292 CH_4 samples, 5.472 N_2O samples. Inside:

+ In 3 rice crops cultivation areas: Kien Giang, Can Tho, An Giang (1M5D, 3R3G and CF)

- **CH_4 samples: 3 models × 4 time (0; 10; 20; 30 minus) × 8 stages × 4 points/model × 3 provinces × 3 crops = 3.456 samples**
- **N_2O samples: 3 models × 4 time (0; 10; 20; 30 minus) × 6 stages × 4 points/model × 3 provinces × 3 crops = 2.592 samples**

+ In 2 rice crops cultivation areas: Long An, Soc Trang, Dong Thap, Hau Giang, and Tien Giang. **(**1M5D, 3R3G, and CF)

- **CH_4 samples: 3 models × 4 time (0; 10; 20; 30 minus) × 8 stages × 4 points/model × 5 provinces × 2 crops = 3.840 samples**
- **N_2O samples: 3 models × 4 time (0; 10; 20; 30 minus) × 6 stages × 4 points/model × 5 provinces × 2 crops = 2.880 samples**

- Observe the growth and development of crops, the situation of pests and diseases, and productivity in 24 models.

GHG Measurement Method at Rice Field

According to the manual for GHG emission measurement in rice cultivation by Institute of Agricultural Environment, Agriculture Publisher, 2016.

Step 1:

- Close the water circulation between the inside and outside of the base chamber by two rubber corks; fill the grove on the top of the base chamber with water.
- Move the top chambers near the sampling points and prepare the required equipment such as batteries, syringes, collection vials, pen, notebook, and stopwatch

Figure 8.7. Illustration for Step 1


Step 2:

- Run fan for air reversal in the chamber by connecting with the batteries
- Install the syringe and the needle into the three-way valve

Figure 8.8. Three-way Valve Structure


- Place the top chamber into the grove of the base
- Close the pressure valve and sample port

Step 3: Sample Collection

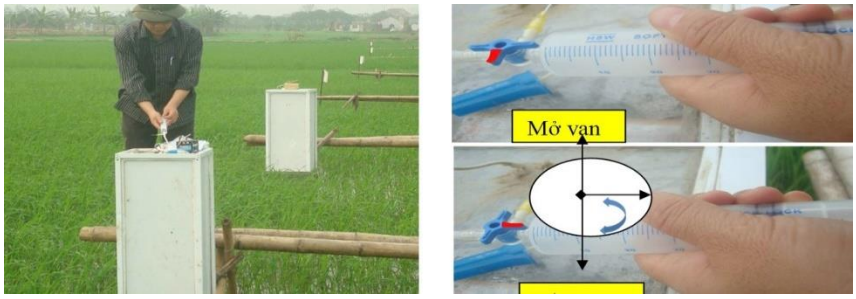
Immediately after placing the top on the base, collect a T_0 sample:

- Turn the three-way valve to open the ventilation between the chamber and the syringe and close the ventilation between the chamber and ambient.
- Draw air until the syringe is full, then return the three-way valve to close the ventilation between the chamber and the syringe and open the ventilation between the syringe and

ambient; push the air outside completely.

- Continuously, turn the three-way valve to open the ventilation between the chamber and the syringe; draw and push air into the syringe five times.
- Until the sixth time, draw 50 ml of air in the chamber and return the three-way valve to close the ventilation between the chamber and the syringe. With the syringe needle, pierce the septum of a 12 ml collection vial and inject the air sample into the vial as much as possible and withdraw the syringe needle from the septum.
- T10, T20, and T30 samples were collected similarly at the timelines of 10, 20, 30 minutes each (interval of 10 minute).
- When the air sampling process is finished, remove the two rubber cork on the wall of the base chamber for water circulation between the inside and outside of the base.

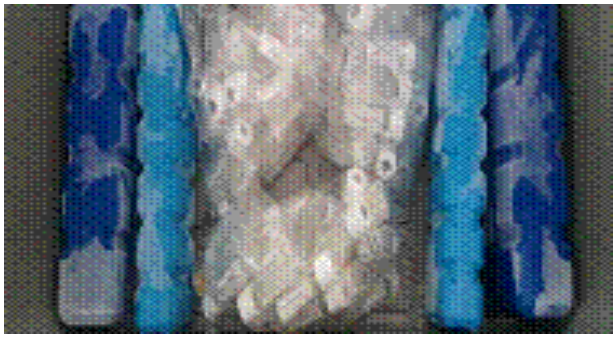
Figure 8.9. Illustration of Step 3



Step 4:

After the sampling process, the sample vials were arranged in batches in the specialized container to prevent from collisions during transport process. The sample should be transferred to the laboratory within 72 h from the sampling time. The sample should be restored in the condition of 25°C temperature and 70–80 percent humidity. The sample should be analyzed within 15 days and no more than 30 days to ensure the accuracy of the results.

Figure 8.10. Container for GHG Sample Storage and Preservation



Method of Gas Sample Analysis and Calculation

The sample was pumped with a carrier gas (usually N_2) into the chromatographic column (static phase). The sample passed through that column would be adsorbed in the static phase. After that, the substances were separated from the column and were recorded by the detector. The signals from the detector would be transferred to a computer that would analyze and display the results in the form of chromatography. The substances were determined by time recorded on the chromatogram.
Optional column:

- Column (PC - 1) - Porapak N 3.2 MM * 2.0 MM * 1 M(Max.Temp.190°C)
- Column (MC - 1) - Hayesep D 3.2 MM * 2.0 MM * 3 M (Max. Temp. 350°C)
- Column (MC - 2) - Hayesep D 3.2 MM * 2.0 MM * 1 M (Max. Temp. 290°C)
- Column (PC - 2) - Porapak N 3.2 MM* 2.0 MM * 1 M (Max.Temp. 190°C)
- Column(MC - 3) - Porapak N 3.2 MM * 2.0 MM * 2 M (Max.Temp. 190°C)
- Column (MC - 4) - MS-13 X 3.2 MM * 2.0 MM * 2 M (Max.Temp. 350°C)
- Column (MC-5) - Porapak Q 3.2 MM * 2.0 MM * 2 M (Max.Temp. 250°C)

Calculation:

The gas fluxes were calculated using the following equation given by Smith and Conen (2004):

$$\mathbf{F} = \left(\frac{\Delta \mathbf{C}}{\Delta \mathbf{t}}\right) * \left(\frac{\mathbf{v}}{\mathbf{A}}\right) * \left(\frac{\mathbf{M}}{\mathbf{V}}\right) * \left(\frac{\mathbf{P}}{\mathbf{P_0}}\right) * \left(\frac{\mathbf{273}}{\mathbf{T}}\right)$$

In which,

- ΔC is the change in concentration of the gas of interest at time interval Δt,
- v and A are the chamber volume and soil surface area respectively,
- M is the molecular weight of the gas of interest,
- V is the volume occupied by 1 mol of the gas at standard temperature and pressure (22.4 L),
- P is the barometric pressure (mbar), P_0 is the standard pressure (1013 mbar).

T is Kelvin temperature (°K).

The cumulative emissions of CH_4 and N_2O were calculated using the trapezoid formula as follows:

$$= (\mathbf{t_b} - \mathbf{t_a}) * \frac{(\mathbf{F_{ta}} - \mathbf{F_{tb}})}{\mathbf{2}} + (\mathbf{t_c} - \mathbf{t_b}) * \frac{\mathbf{F_{tb}} + \mathbf{F_{tc}}}{\mathbf{2}} + \cdots + (\mathbf{t_n} - \mathbf{t_x}) * \frac{\mathbf{F_{tn}} + \mathbf{F_{tx}}}{\mathbf{2}}$$

where t_a, t_b, t_c are the dates of the first, second and third sampling; t_n is date of the last sampling; t_x is the date before the last sampling; and F_{ta}, F_{tb}, F_{tc}, F_{tx} and F_{tn} are the fluxes of gas of interest on the t_a, t_b,t_c, t_x, and t_c sampling days.

Calculation of total CH_4; N_2O emission in the whole cropping season (△d days from transplanting to harvesting) follows the formula:

CH_4 (mg C/m^2/cropping season) = ∑ CH_4 (mg C/m^2/hr) × 24 hours × △d
N_2O (mg N/m^2/cropping season) = ∑ N_2O (mg N/m^2/hr) × 24 hours × △d

According to IPCC 2007, Global Warming Potential (GWP) was estimated by converting all GHGs into CO_2equivalents (CO_2eq)

Factor converting CH_4 into CO_2 = CH_4 × 25
Factor converting N_2O into CO_2 = N_2O × 298 (Forster et al., 2007).
Total GHG emission is calculated via the following formula:

GWP = CO_2 emission + CH_4 emission × 25 + N_2O emission × 298