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IMPLEMENTATION COMPLETION AND RESULTS REPORT

TF 17649

ON A

GRANT

FROM THE GLOBAL ENVIRONMENT FACILITY

IN THE AMOUNT OF US$5.1 MILLION

TO THE

PEOPLE'S REPUBLIC OF CHINA

FOR A

Climate Smart Staple Crop Production

June 18, 2021

Agriculture And Food Global Practice
East Asia And Pacific Region

CURRENCY EQUIVALENTS

(Exchange Rate Effective September 30, 2020)

Currency Unit =	CNY
CNY =	US$0.15
US1$ =	6.47 CNY

CALENDAR YEAR
January1 - December 31

Regional Vice President:	Victoria Kwakwa
Country Director:	Martin Raiser
Regional Director:	Benoit Bosquet
Practice Manager:	Dina Umali-Deininger
Task Team Leader(s):	Jianwen Liu, Ladisy Komba Chengula
ICR Main Contributors:	Xueming Liu, Armine Juergenliemk

ABBREVIATIONS AND ACRONYMS

CSA	Climate Smart Agriculture
CLG	County Leading Group
DA	Designated Account
DOA	Department of Agriculture
ERR	Economic Rate of Return
FIRR	Financial Internal Rate of Return
FM	Financial Management
FYP	Five Year Plan
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEO	Global Environmental Objective
GHG	Greenhouse Gas (main GHG emissions from agriculture and land use carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)).
GIS	Geographic Information System
Ha	Hectare
IPM	Integrated Pest Management
M&E	Monitoring and Evaluation
MARA	Ministry of Agriculture and Rural Affairs (Ministry of Agriculture before the government re-organization in 2018)
MOA	Ministry of Agriculture
MOF	Ministry of Finance
NDRC	National Development and Reform Commission
NEG	National Expert Group
NPD	National Project Director
NPSC	National Project Steering Committee
PDO	Project Development Objective
PIM	Project Implementation Manual
PLG	Provincial Leading Group
PMO	Project Management Office
PMP	Pest Management Plan
PMU	Project Management Unit
RPF	Resettlement Policy Framework
SOC	Soil Organic Carbon

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DATA SHEET

BASIC INFORMATION

Product Information

Project ID	Project Name
P144531	Climate Smart Staple Crop Production
Country	**Financing Instrument**
China	Investment Project Financing
Original EA Category	**Revised EA Category**
Partial Assessment (B)	Partial Assessment (B)

Organizations

Borrower	Implementing Agency
PEOPLE'S REPUBLIC OF CHINA	Ministry of Agriculture and Rural Affairs

Project Development Objective (PDO)

Original PDO

The project's Development Objective (PDO) and its Global Environmental Objective (GEO) is to demonstrate climate smart and sustainable staple crop production in Huaiyuan County of Anhui Province and Yexian County of Henan Province.

FINANCING

	Original Amount (US$)	Revised Amount (US$)	Actual Disbursed (US$)
World Bank Financing			
TF-17649	5,100,000	5,081,083	5,081,083
Total	**5,100,000**	**5,081,083**	**5,081,083**
Non-World Bank Financing			
Borrower/Recipient	25,000,000	25,000,000	28,400,000
Total	**25,000,000**	**25,000,000**	**28,400,000**
Total Project Cost	**30,100,000**	**30,081,083**	**33,481,083**

KEY DATES

Approval	Effectiveness	MTR Review	Original Closing	Actual Closing
29-Aug-2014	01-Dec-2014	28-May-2018	31-Mar-2020	30-Sep-2020

RESTRUCTURING AND/OR ADDITIONAL FINANCING

Date(s)	Amount Disbursed (US$M)	Key Revisions
06-Apr-2019	3.22	Change in Loan Closing Date(s) Reallocation between Disbursement Categories

KEY RATINGS

Outcome	Bank Performance	M&E Quality
Satisfactory	Satisfactory	Substantial

RATINGS OF PROJECT PERFORMANCE IN ISRs

No.	Date ISR Archived	DO Rating	IP Rating	Actual Disbursements (US$M)
01	25-Nov-2014	Satisfactory	Satisfactory	0
02	12-May-2015	Satisfactory	Moderately Satisfactory	0

03	02-Nov-2015	Satisfactory	Satisfactory	1.00
04	08-May-2016	Satisfactory	Satisfactory	1.04
05	21-Nov-2016	Satisfactory	Satisfactory	1.04
06	09-Jun-2017	Satisfactory	Satisfactory	1.68
07	22-Nov-2017	Satisfactory	Satisfactory	1.23
08	28-Jun-2018	Moderately Satisfactory	Moderately Satisfactory	2.82
09	08-Jan-2019	Moderately Satisfactory	Moderately Satisfactory	2.82
10	26-Jun-2019	Satisfactory	Moderately Satisfactory	3.22
11	26-Dec-2019	Satisfactory	Moderately Satisfactory	3.57
12	30-Jun-2020	Satisfactory	Moderately Satisfactory	4.40

SECTORS AND THEMES

Sectors

Major Sector/Sector	(%)
Agriculture, Fishing and Forestry	**100**
Agricultural Extension, Research, and Other Support Activities	39
Crops	48
Public Administration - Agriculture, Fishing & Forestry	13

Themes

Major Theme/ Theme (Level 2)/ Theme (Level 3)	(%)
Finance	**6**
Finance for Development	6
Agriculture Finance	6
Urban and Rural Development	**6**
Rural Development	6
Rural Markets	6
Environment and Natural Resource Management	**89**
Climate change	89
Mitigation	89

ADM STAFF

Role	At Approval	At ICR
Vice President:	Axel van Trotsenburg	Victoria Kwakwa
Country Director:	Klaus Rohland	Martin Raiser
Director:	Juergen Voegele	Benoit Bosquet
Practice Manager/Manager:	Iain G. Shuker	Dina Umali-Deininger
Project Team Leader:	Jiang Ru	Jianwen Liu, Ladisy Komba Chengula
ICR Co Author:		Armine Juergenliemk

I. PROJECT CONTEXT AND DEVELOPMENT OBJECTIVES

A. CONTEXT AT APPRAISAL

Context

1. **China's greenhouse gas emissions contribute significantly to global climate change.** China has strived to integrate climate smart development actions into its green growth strategy. In doing so, the Government developed the National Program on Climate Change (2007), the White Paper on China's Policies and Actions for Addressing Climate Change (2011) and the Work Plan for Greenhouse Gas Emissions Control during the Period of the 12th Five-Year Plan (FYP) for National Economic and Social Development (2011). Consistent with these policy frameworks, the Government's Action Program on Climate Change for Agriculture (2008) emphasized sustainable crop production systems to enhance crop yields and farmer incomes while reducing greenhouse gas (GHG) emissions and promoting resilience to climate change in crop production systems. The Government has emphasized the importance of promoting sustainable crop production technologies and establishing scientific monitoring and evaluation (M&E) methods to ensure effective GHG emissions reductions from crop production. It also stressed the need for capacity building to adapt to a changing climate that is expected to be hotter nationwide, with increased drought risk in Northern China, and floods in Southern China.

2. **China's agriculture sector has supported 22 percent of the world's population with only 7 percent of the world's arable land.** To achieve food security, China developed intensive crop production systems that relied on excessive and inefficient use of fertilizers, pesticides, and irrigation water inputs. The result is significant GHG emissions in China's crop production. Heavy reliance on synthetic fertilizers also stressed China's limited arable land. China's cropland accounts for over 70 percent of its total arable land area. soil organic carbon (SOC) in typical cropland of China is 30 percent lower than the world average and over 50 percent lower than Europe's. This situation was aggravated by unsustainable crop production practices that often included excessive tillage, straw burning, and low rates of organic residue return to soil, mono-cropping or limited crop rotation, and flood irrigation. These practices led to high GHG emissions from crop production and reduced the resilience of China's crop production systems to climate change.

3. **There was a high potential for climate change mitigation and adaptation actions to improve the economic and environmental performance of its crop production given high inputs use with low efficiency and low SOC content.** Within the food systems identified, excessive fertilizer use, particularly nitrogen-based fertilizers, and flooded rice were major contributors to GHG emissions – specifically nitrous oxide and methane. Recognizing this, both on its own and collaborating with international organizations, including the World Bank, China implemented a program to pilot low GHG emissions and soil carbon sequestration technologies (such as precision fertilization and crop residue retention in the field) to reduce net emissions from the agriculture sector. China also continued to improve its irrigation infrastructure and promote water-saving irrigation, stress-resistant crop varieties and diversifying cropping systems to improve climate resilience of its crop production systems. A key focus of China's initiatives was introducing farmers to technologies and practices (e.g., precision fertilization and no-till land preparation) that could promote the efficient use of GHG intensive synthetic inputs, improve soil productivity, and achieve sustainable crop yields. These actions complied with the principles of climate smart agriculture (CSA), which aim to: (a) sustainably improve agricultural productivity, increase farm incomes, strengthen food security and promote equitable development; (b) adapt and build the resilience of agricultural and food security systems to climate change at multiple scales; and (c) reduce and/or remove GHG emissions from agriculture whenever

possible.

4. **The Ministry of Agriculture (MOA aka MARA)[1] identified multiple factors limiting the uptake of climate smart crop production technologies in China:** (a) limited public support for screening and assessing agricultural technologies; (b) inadequate demonstration on the ground; (c) limited awareness of CSA practices by farmers and local governments; (d) lack of policy incentives for CSA development; and (e) low capacity of extension services to disseminate advisories to farmers. To address these challenges and promote identification and adoption of context-specific climate smart crop production technologies, MARA requested the Bank's support to prepare and implement this project financed by a grant from the Global Environment Facility (GEF).

5. **The project directly addressed a key strategic theme of the Bank's Country Partnership Strategy for China (2013-2016):** supporting greener growth by promoting sustainable agricultural practices that improve water and farm productivity, produce quality and safe products, and the agricultural sector's ability to adapt to climate change.

6. **This project was an integral part of China's efforts to address climate change in the agricultural sector.** Successful project implementation would contribute to the country's efforts to reduce China's GHG emissions per unit of Gross Domestic Product (GDP) by 40-45 percent by 2020 compared to its 2005 level. At a higher level, the project would contribute to global efforts to reduce GHG emissions, and help project farmers improve their crop productivity and income, complement the government's ongoing poverty reduction efforts, and support the Bank's twin goals, eliminating extreme poverty and boosting shared prosperity.

Theory of Change (Results Chain)

7. The theory of change (TOC) is constructed retroactively by the ICR team as Project Appraisal Document did not include a TOC. The PAD identified a number of factors limiting the uptake of climate smart crop production technologies in China (see paragraphs 3 and 4). The project addressed these constraints by: (a) demonstrating that CSA technologies (i.e. GHG emission reduction and efficient irrigation techniques; carbon sequestration techniques; new production technique pilots) can generate intended public goods (climate benefits) and financial profitability for farmers with public support; and (b) supporting CSA related policies and knowledge development (CSA policies, strategy and guidelines; provincial and national level dissemination of project knowledge). The project PDO (see below) was achieved by reducing GHG emissions and increasing carbon sequestration and yields.

[1] MOA became Ministry of Agriculture and Rural Affairs (MARA) following the government re-organization in 2018.

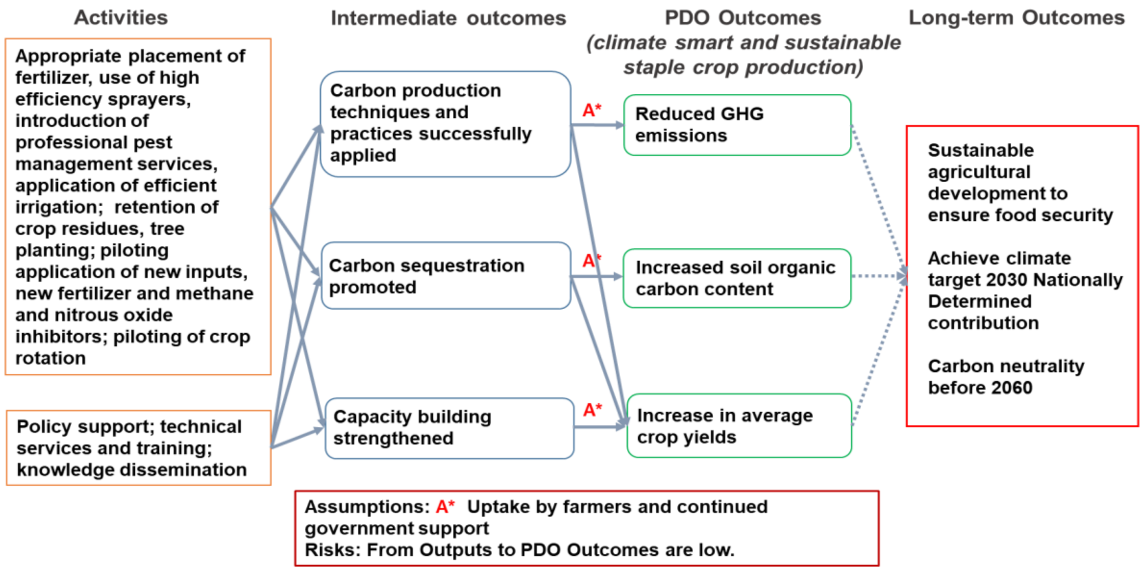

Figure 1. Theory of Change

Project Development Objectives (PDOs)

8. The Project Development Objective (PDO) and its Global Environmental Objective (GEO) is to demonstrate climate smart and sustainable staple crop production in Huaiyuan County of Anhui Province and Yexian County of Henan Province.

Key Expected Outcomes and Outcome Indicators

9. The key expected outcomes are effects/benefits from demonstrating climate smart and sustainable staple crop production, namely reduced GHG emissions, increased carbon sequestration and increased crop yields, as measured by:
   (a) Reduced GHG emissions, with end target at 21,000 ton (CO_2 equivalent)[2],
   (b) Increased soil organic carbon content with end target at 44,000 (CO_2 equivalent), and
   (c) Change in average crop yields, with end target at 8 percent.

Components

10. The project was comprised of the following three components:

11. **Component 1: CSA Demonstration** (Estimated Cost: US$ 23.96million with GEF funding at US$ 3.96 million and government financing US$ 20.00 million; Actual Cost: US$ 27.02 million with GEF funding at US$ 3.96 million and government financing US$ 23.06 million). This component financed:

[2] CO_2 equivalent (CO_2.eq) emission: The amount of carbon dioxide (CO2) emission that would cause the same integrated radiative forcing or temperature change, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs. In this document the following main agriculture and land use GHG emissions are monitored: main GHG emissions from agriculture and land use carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

(a) Demonstrating GHG emissions reduction and efficient irrigation techniques, including: (i) appropriate dose, formulation and placement of fertilizers in soil for demonstrating high fertilizer use efficiency; (ii) promoting high-efficiency sprayers and professional pest management services; and (iii) efficient irrigation practices that promote water and energy savings in rice and wheat and lower GHG emission in rice production.
(b) Demonstrating carbon sequestration techniques, covering: (i) retention of crop residues, focused on rice straw management in Huaiyuan and improved stalk shredding with large machinery in Yexian; and (ii) tree planting around project area croplands to increase soil organic carbon and integrate trees into cropping systems.
(c) New production technique pilots, including: (i) applications of new inputs, biochar produced from wheat straw and corn straw as soil amendment on a small scale in Huaiyuan and Yexian, respectively; (ii) application of new fertilizers and methane inhibitors for rice production in Huaiyuan; and (iii) improved retention of corn stalks and no-till wheat planting techniques in Yexian.
(d) Technical support for CSA demonstration, including: (i) a national expert group (NEG), composed of specialists in crop production, soil and fertilization, plant protection, agronomy and agricultural machinery, and monitoring of GHG mitigation activities; (ii) technical services and training; and (iii) farmer field schools.
(e) Monitoring and evaluation (M&E), covering: (i) CSA M&E; (ii) social impact monitoring; (iii) environmental safeguard monitoring; and (iv) management of project data and information based on a geographic information system (GIS). In addition, control groups were identified and monitored for Activities (i) and (ii) to ensure observed changes in results indicators are the result of project impacts.

12. **Component 2: Policy Development and Knowledge Management** (Estimated Cost: US$ 3.90 million with GEF funding at US$ 0.90 million and government financing US$ 3.00 million; Actual Cost: US$ 4.21 million with GEF funding at US$ 0.9 million and government financing US$ 3.31 million). This component supported:

(a) Development of National CSA Policies, Strategies and Guidelines, covering: (i) the national CSA policy and strategy; (ii) integrating CSA concepts into China's food security strategy; (iii) two CSA guidelines for staple crop production; and (iv) a methodology for quantifying GHG mitigation associated with the implementing CSA technologies and practices in staple crop production in China.
(b) Provincial and National Dissemination of Project Knowledge. The project supported documenting lessons learned and developing a project website as a knowledge exchange platform to help project beneficiaries and stakeholders access project information. Project newsletters and promotional materials were prepared to disseminate the progress and results of project implementation and successful project experiences and lessons learned. In the two project provinces, dissemination activities were organized to educate farmers and extension service technicians from non-project townships surrounding the project areas, and eventually to the rest of the provinces. Project experience were disseminated nationally through the MARA network.
(c) Sub-component 2(c): Promotion of International CSA Cooperation. The project supported MARA participation in related international CSA and GEF climate mitigation events to learn from international best practices as well as to present this project's results internationally.

13. **Component 3. Project Management** (Estimated Cost: US$ 2.24 million with GEF funding at US$ 0.24 million and government financing US$ 2.00 million; Actual Cost: US$2.26 million with GEF funding at US$ 0.24 million and government financing US$ 2.02 million). This component supported project implementing agencies to manage, supervise and monitor project implementation.

B. SIGNIFICANT CHANGES DURING IMPLEMENTATION

14. There was one restructuring in May 2018 (see details below).

Revised PDOs and Outcome Targets

15. The PDO and outcome targets were not changed.

Revised PDO Indicators

16. The PDO indicators were not changed.

Revised Components

17. The project components were not revised.

Other Changes

18. **Changes in Disbursement Categories.** Reduced funds for sub-grants and subsidies in Category (1) from US$1,936,000 to US$1,590,000 and increased funds for goods and non-consulting and consulting services in Category (2) from US$3,164,000 to US$3,510,000.

19. **Changes in Implementation Schedule.** The project loan closing date was extended from March 31, 2020 to September 30, 2020 to enable the completion of the newly added activities.

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

20. **The changes made at project restructuring did not alter the TOC as reconstructed above; they provided extra time for completing activities and piloting new technologies.** The slow start to project implementation led to a need to allow extra time to implement activities related to winter wheat. Lengthier preparation and implementation delays resulted in missing the 2015 winter season for wheat, delaying implementation to Autumn 2015, for an overall delay of one more crop season to complete the planned activities for winter wheat.

21. **Piloting CSA activities required more time to complete because of the initial delays and also due a longer time to introduce the new technologies to be tested under the project (which required initial testing, and time to collect and assess the results).** The implementing agencies increased conservation agriculture (CA) piloting to test three modalities: (a) traditional tillage (CK): straw return + deep ploughing; (b) CA with Chinese characteristics CA (T1): straw return + rotary tillage; and (c) system-based CA (T2): straw mulching + no-tillage + crop rotation. Other new technologies for piloting in the project counties included adopting new crop varieties and seed treatment techniques, low-till/no-till, and crop straw mulching, etc.

22. **Monitoring and evaluating GHG emissions reduction and carbon sequestration results needed more time for data collection and analysis.** Coupled with the delay in project implementation, M&E data for winter wheat missed one crop season. Extending the project closing date provided time to monitor and evaluate all the

implemented activities, including those related to winter wheat, enabling the fair evaluation of project implementation results against project targets.

23. **The project extension also provided extra time for policy studies and knowledge management.** The fund re-allocation allowed project implementation units to purchase additional machinery to pilot new technologies such as fertigation, full conservation agriculture, climate adaptive planting technologies, and ecological interception technologies to enhance GHG emissions reduction and CO_2 sequestration while increasing crop yields.

II. OUTCOME

A. RELEVANCE OF PDOs

Assessment of Relevance of PDOs and Rating

24. **The PDO remains highly relevant and fully aligned with World Bank's Country Partnership Framework (CPF, Report No. 117875-CN) for 2020-2025, and the new phase of the World Bank's China engagement at project closing.** The CPF focuses on China's remaining institutional gaps and contributions to global public goods, a shift that is consistent with China's own development strategy as an upper middle-income country pursuing a rebalanced and greener growth model. The project contributed directly to the second pillar of the CPF that aims to promote greener growth, and more specifically to CPF objective 2.3 – to demonstrate sustainable agriculture practices and safer and higher quality food systems by reducing GHGs, enhancing carbon sequestration and adopting integrated pest management (IPM). The project interventions for reducing GHGs and formulating relevant policy advice fit well with the CPF's selectivity criteria, namely, strengthening policies and institutions, addressing regional and global public goods, and strategically piloting approaches addressing key development priorities. Many of the lessons and knowledge generated are highly relevant for addressing CSA issues elsewhere and have been scaled up in other parts of China (See Section E), with potential replications internationally.

25. **The PDO was well aligned with China's national priorities as articulated in the 12th FYP (2011-2015) at project appraisal and the 13th FYP (2016-2020) at project closure.** The Government of China has committed to addressing environmental and climate challenges by reducing emissions from its economic activities, including agriculture. Further, the Chinese government reconfirmed that reducing agriculture's climate footprint is a top priority as specified in multiple policy documents throughout project implementation, including the annual No. 1 Central Document, the Sustainable Agricultural Modernization Plan, and the Rural Revitalization Strategy and Ecological Civilization Strategy. All of them have put a priority on agricultural sustainability and reducing agriculture's climate footprint.

26. **The project design was also visionary and forward-looking and directly contributed to implementing China's Nationally Determined Contribution (NDC).[3]** China has pledged to lower carbon dioxide emissions per unit of GDP by 60 percent to 65 percent from the 2005 level by 2030. China also declared to proactively adapt to climate change by enhancing mechanisms and capacities to effectively defend against climate change risks in key areas such as agriculture, forestry, and water resources. At project inception, China's aim was to: (a) promote low-carbon development in agriculture, making efforts to achieve zero growth of fertilizer and pesticide use by 2020; (b) control methane emissions from rice fields and nitrous oxide emissions from farmland; (c) construct a

[3] Source: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/China%20First/China's%20First%20NDC%20Submission.pdf

recyclable agriculture system, promoting comprehensive uses of straw, agricultural and forestry wastes, and comprehensive use animal waste; (d) improve the construction of water conservation facilities for farmlands, develop water-saving agricultural irrigation and cultivate heat- and drought-resistant crops; (e) develop technologies in biological nitrogen fixation, green pest and disease prevention and control; and technologies and infrastructure that improve agriculture resilience; (f) improve greenhouse gas emission statistics covering areas including energy activity, industrial process, agriculture, land-use change, forestry and waste treatment; and (g) improve technical support systems for addressing climate change and strengthening professional personnel training for addressing climate change.

27. **The relevance of the PDO is rated as *High*,** considering the project's objectives are in close alignment with the current Bank CPF and government development priorities as stated above.

B. ACHIEVEMENT OF PDOs (EFFICACY)

28. **Unpacking the PDO.** The PDO and the Global Environmental Objective (GEO) is demonstrating climate smart and sustainable staple crop production in both Huaiyuan County in Anhui Province and Yexian County in Henan Province. This was achieved through field-level demonstration of climate change mitigation and adaptation techniques and practices in China's three main staple crops under two major crop production systems: the rice-wheat system in Huaiyuan and the wheat-corn system in Yexian.

29. Climate-smart agriculture (CSA) is defined as "an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support the development and ensure food security in a changing climate. CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible".[4]

30. There are close linkages among and between these three aspects: climate resilience to ensure food security, environmental sustainability, and climate change mitigation. The sustainability of project promoted CSA interventions depends on the cost-effectiveness of the technical measures adopted in reducing GHG emissions, increasing carbon sequestration and improving the climate resilience of crop production systems both now and in the future. More importantly, the project's sustainability depends on whether it can increase (or at least maintain) productivity as measured by crop yields, thereby ensuring food security, in the context of Chinese agriculture development. Agricultural resilience to climate change impacts are also measured by productivity increases that result from adopting new crops and technologies to climate change.

31. CSA technical interventions introduced in the project include: (a) energy-efficient irrigation infrastructure; (b) water-saving production techniques; (c) stress-resistant varieties; (d) improved inputs management (pesticides and fertilizers); (e) increased soil organic carbon though improved soil and straw management; (f) diversified cropping systems and agricultural systems (i.e. piloting fish-rice farms, and crop rotation), and (g) tree planting around the farms. The interventions generated simultaneously benefits from net GHG emission reduction, sustainability and climate resilience.

32. The key project outcomes are actually effects/benefits from demonstrating climate smart and sustainable staple crop production as reflected in the inter-linked three dimensions, namely, greenhouse gas emissions reduction

[4] See FAO's Official Site for CAS (http://www.fao.org/climate-smart-agriculture/en/).

and/or removal, environmental sustainability and climate resilience. Specifically, for evaluation purpose and per the design of PDO indicators, reducing and removing greenhouse gas emissions is measured by the first two Outcome Indicators: "Reduced GHG Emission" and "Increase in Carbon Sequestration", while sustainability and resilience are measured by the third Outcome Indicator, "Crop Yield Increases".

Assessment of Achievement of Each Objective/Outcome

33. **Overall Assessment.** The demonstrated technologies and good agricultural practices (GAPs) were implemented on a total area of 6,667 hectares (100,000 mu) in Huaiyuan and Yexian Counties. Using the baseline production practices and international and domestic best practices, applicable CSA interventions were identified for key crop production processes (e.g. variety selection, field preparation, sowing, tillage, nutrient and water management, pest and disease management, harvesting, crop residue management, agroforestry integration) used within each cropping system. Crop rotation options for the two cropping systems were also tested. Selected CSA interventions were then divided into two groups: known technical options and technical options needing testing. The known technical options (such as precision fertilization, integrated pest management, water management, and crop residue management) were being promoted in the project areas and/or in China. The second group of options (such as conservation agriculture for rice production, biochar application, and crop rotation) were relatively new to targeted farmers or had not yet been tested in the project areas or even in China. The first group of known CSA interventions was demonstrated under the project at a large scale, while the second group of interventions was piloted at a small-scale first and scaled up selectively based on the demonstrated on-the-ground results. The selected technical interventions effectively reduced GHG emissions and increased carbon sequestration, and also reduced farming costs, increased yield, increased farmers' net income and generated additional environmental benefits (see Additional Benefits section).

34. The Chinese government, through counterpart funding, financed most (85 percent) of the project cost to: (a) improve water-saving irrigation facilities and introduce efficient irrigation techniques, and (b) plant trees around croplands in the project areas to increase soil organic carbon and carbon sequestration in aboveground biomass, and integrate trees into cropping systems. Those activities directly contributed to achieving the PDOs.

35. Overall, this public support allowed to generate evidence about the feasibility of the CSA approach through collaborations with academia, addressed the key barriers of the CSA adoption such as limited financing and access to affordable capital, upfront investment costs (e.g. costs of investment in equipment, machinery) and mainstreaming the key findings into the national policymaking process.

Reducing/removing GHG Emissions (Rated High)

36. This outcome was measured by: (a) Reduced GHG Emission (baseline: 0, target: 21,000, actual result: 29,782 tons of CO_2-eq, exceeding the original target by 41 percent); and (b) Increase in Carbon Sequestration indicator (baseline: 0, target: 44,000, actual result: 99,565 tons of CO_2-eq, exceeding the project end targets by 126 percent). Two other intermediate results indicators were used to measure the non-CO_2 GHG emissions reduction: (c) Reduction in inputs – fertilizer (baseline: 0, target: 500, actual result: 572), and (d) Reduction in inputs – pesticides (baseline: 0, target: 100, actual result: 121).

37. Higher cumulative GHG emissions reductions were achieved in Anhui since methane (CH_4) emissions declined due to improved water management (financed by the government counterpart funding in the rice fields) and decreased nitrous oxide (N_2O) emissions predominantly through improved use of inputs in wheat production. In

Yexian, net GHG emissions reductions were achieved by decreasing N_2O emissions through improved use of inputs in wheat production.

38. **Justification of the causal relationship between project interventions and outcomes.** It is well recognized by both academia and practitioners[5] that net GHG emissions reduction can be achieved through: (a) reducing and improving fertilizer use (such as use of formula fertilizers) through appropriate dose, formulation and placement of fertilizers in soil based on soil testing results and the nutrient needs of crops during different growth periods; (b) use of high efficiency sprayers and professional pest management services; and (c) efficient irrigation practices that promote water and energy savings in rice and wheat and lower GHG emissions in rice production.

39. **Sound methodologies to quantify GHG emissions reduction were adopted at appraisal and during the implementation, ensuring accurate and reliable outcome values (See Section IV.A on M&E).**

Environmental sustainability and climate resilience (Rated Substantial)

40. **All projected crop annual yield increases were achieved** (see Annex 1). Specifically, farmer beneficiaries participating in the project pilots increased their crop yield by 8 percent and their income by 14 percent. At project closure, the crop yield increase reached 8.02 percent, exceeding the end target of 8 percent by a small margin. This demonstrates that CSA approaches can simultaneously address the interlinked challenges of food security and climate change by: (a) sustainably improving agricultural productivity; (b) adapting and building the resilience of agriculture and food systems to climate change through water savings; and (c) reducing and/or removing greenhouse gas (GHG) emissions from agriculture production. The rating for this outcome is *Substantial.*

41. The project built climate resilience and environmental sustainability through implementation activities including: (a) rehabilitating irrigation infrastructure; (b) water-saving production techniques[6]; (c) using stress resistant varieties; (d) pest management; and (e) diversifying both cropping and agricultural systems (e.g., piloting fish-rice farming and crop rotation). The “Reduction in inputs – water” (baseline: 0, target: 1,000,000, actual result: 1,450,000 M^3) intermediate indicator demonstrates improved water use efficiency.

42. Crop productivity was monitored through surveys of project farm households through the change in average crop yield. The sampling approach and procedures followed those in the baseline survey (See Section IV.A).

Additional project outcomes

43. The project had substantial impacts on capacity building and institutional strengthening at various levels, such as (See Section III.E): (a) Farmer-centered training and mobilization, particularly through project-organized farmer’s field schools[7] that increased the adoption of CSA practices; (b) at provincial/county levels in building the awareness of CSA options and designing local CSA programs; (c) at the national level by sharing the CSSCP experiences with other provinces and globally (the Climate Smart Agriculture International Forum, See Section II.E) and (d) strengthening the scientific/technical capacity of the participating local M&E experts/local academic/research agencies by introducing methodologies used by international institutions to measure GHG emissions and other environmental benefits (see more details in Section E). Intermediate indicators related to

[5] See Climate-Smart Agriculture Sourcebook. http://www.fao.org/3/i7994e/i7994e.pdf
[6] Water saving practices include alternative wetting, canal lining and land leveling to reduce irrigation water use and optimize irrigation scheduling.
[7] See Annex 7: Voices and Faces of Farmers’ Participation in Project Implementation.

capacity building included (e) "Client days of training provided" (baseline: 0, target: 25,000, actual result: 25,016); and (f) "Number of farmer field schools under proper operation" (baseline: 0, target: 30, actual result: 30).

44. Annex 7 was prepared to highlight farmers' perspectives to the project outcomes and impacts, including their personal reflections, quotations, and pictures.

45. **The demonstrated CSA technologies and practices produced additional environmental co-benefits.** The reduced use of fertilizers and agrochemicals decreased waterway and air pollution and mitigated soil acidification and mineral depletion due to high inputs. Using high efficiency sprayers and professional pest management reduced pollution, conserved pollinator biodiversity, and reduced adverse human health impacts from handling pesticides. Efficient irrigation technologies reduced both energy and water use. Retaining crop residues eliminated adverse effects of crop residue burning that generate smog, which then causes health hazards, biodiversity loss, and reduces soil fertility. Tree planting around croplands improved water and air quality, soil health, and wildlife habitat.

Justification of Overall Efficacy Rating

46. **The overall Efficacy is rated as *Substantial,*** given the High rating for the CSA demonstration outcome and Substantial for the demonstration of Sustainability.

C. EFFICIENCY

Assessment of Efficiency and Rating

47. **Economic Analysis.** Following the approach adopted at appraisal, a cost-benefit analysis was conducted to re-assess the project's ex-post economic viability at completion. The analysis was performed at the project level for the aggregated interventions, using the "with/without project" comparison approach. The incremental economic costs included: (a) investment for adopting new technologies; (b) operational costs for agricultural production; and (c) project management and capacity-building costs. The major benefits included in the analysis were: (a) improved agricultural production; (b) savings from reduced agricultural input costs, including fertilizer, agro-chemicals, diesel, and irrigation water; and (c) environmental benefits from GHG emissions reduction. Based on the identified incremental benefits and costs, the Economic Internal Rate of Return (EIRR) of the project was calculated with both low and high economic prices for carbon reduction. As such, the EIRR for Yexian County was estimated at a low of 31 percent (carbon shadow price at US$ 40/ton) and high of 35 percent (carbon shadow price at US$ 80/ton with annual growth rate at 2.25 percent) respectively, and for Huaiyuan County, a low of 44 percent and high of 45 percent, indicating the project was economically viable and robust. The output prices and yield increase at ICR were close to those assumed at appraisal. Given that, the project EIRR, if adopting the carbon shadow price (US$6/ton) at appraisal, would be at 18 percent, comparable with the appraisal estimate (19 percent for the whole project). The noticeably higher EIRRs at ICR were mainly due to the much higher carbon shadow prices adopted at ICR per the World Bank's guidance note[8] compared to that at appraisal.

48. The project EIRRs were conservative since other environmental benefits, such as less air pollution from reduced crop residue burning and less groundwater pollution from overuse of fertilizer and agro-chemicals, were not included as they were not readily quantifiable.

[8] Guidance note on shadow price of carbon in economic analysis, the World Bank, 2017.

49. **The financial analysis was carried out at the household level by comparing "with" and "without" situations for various project interventions.** The incremental project costs and benefits were based on M&E data collected on: (a) crop yield changes; (b) agricultural input reduction; and (c) actual investment costs. The analysis concluded that even without government subsidies, some project interventions, such as IPM and water-saving irrigation practices, were financially viable. They all had financial internal rate of returns (FIRRs) above the financial discount rate of 12 percent, as adopted by key commercial banks in China to assess financial viability. For those activities, an initial subsidy was justified to incentivize farmers to try the new technical packages. Once these activities were proven to be financially profitable, farmers would continue using them even without subsidies. Other project interventions, such as conservation tillage and mechanized crop residue retention in field, were not financially viable without subsidies, as they mainly generated positive externalities (carbon sequestration and decreased GHG emissions) that could not be internalized by farmers. Given the importance of these activities in generating climate co-benefits and ecosystem services, subsidies should be continued and even increased to ensure the sustainability and up-scaling. Therefore, realigning agricultural support to promote CSA, including payments for carbon sequestration, provides an untapped opportunity to deliver public goods and improve the livelihoods of rural populations.

50. The above analysis indicates that CSA technologies should qualify for the current government payment for ecosystem service (PES) program. In fact, the "subsidies" provided to farmers are all well founded and are an effective means to achieving much more valuable climate benefits. The analysis shows that each and every technical intervention can generate climate benefits, justifying subsidies to farmers. Since farmers cannot internalize the positive externalities that are generated by these practices, it is fair to fully recognize and fairly compensate farmers via subsidies for delivering a public good.

51. The different CSA technologies provide different levels of GHG emissions reduction and carbon sink; therefore, government compensation should be well targeted based on specific crop/activity implementation results to ensure that public financing is efficiently and effectively used. As different technical interventions generated divergent financial returns for farmers and economic returns for society as a whole, the subsidies should target and focus on those generating higher public goods.

52. **Implementation Efficiency.** The procurement and financial management performance were generally satisfactory (See Section IV.B). Project restructuring with a six-month closing date extension was clearly justified (See Section I.B). Although project implementation progress was delayed at a late stage due to COVID-19 epidemic outbreak (See Section III.B), all project activities (including those added at project restructuring) were completed before the project closure. Government financing (mainly for irrigation infrastructure and tree planting around farmland) accounted for 85 percent of the total project cost, laying a solid foundation for other CSA interventions funded by the GEF grant (15 percent of the total project cost). The actual counterpart financing exceeded the approved budget by 14 percent, resulting in larger a larger project area. The GEF grant was close to full disbursement at the project closure (99.6 percent).

53. **The Efficiency is rated as *Substantial* based on above assessment.**

D. JUSTIFICATION OF OVERALL OUTCOME RATING

54. **The overall outcome of the project is rated Satisfactory based on High Relevance, Substantial Efficacy and Substantial Efficiency.**

E. OTHER OUTCOMES AND IMPACTS

Gender

55. **With a large number of migrant workers (predominately male) moving to urban areas, female farmers made up more than 50 percent of the rural workforce.** Based on the field survey conducted by the county project management units (PMUs), the project generated some 2,000 job opportunities for rural women, and women accounted for 60 percent of the total participants of various training and capacity-building activities. Agricultural mechanization reduced women's labor intensity and reduced use of fertilizer and pesticide in agricultural production mitigated exposure for female farmers to health hazards. Increased yields, and associated income further supported women farmers and their households.

Institutional Strengthening

56. **The project had substantial impacts on the institutional strengthening through Component 2 (Policy Development and Knowledge Management). Specifically, the project conducted the following studies for policy advice and technical guidelines:**

(a) **The National CSA Policy and Strategy**. The first study on China's CSA policy and strategy examined how existing agricultural policies could be adjusted and optimized to support CSA adoption and knowledge dissemination. The study also explored whether an ecological compensation scheme could be developed to sustain project support and promote climate smart crop production nationally. It proposed strategies to support MARA to continue its efforts to screen, assess, pilot and disseminate future CSA techniques.

(b) **Integrating the CSA Concept into China's Food Security Strategy.** This study examined how to integrate CSA concept into China's food security strategy to re-orient the government's policy priority from ensuring "quantity" alone to both "quantity" and "sustainability". In particular, the study used the verified impacts of CSA techniques on crop yields and GHG emissions reduction and carbon sequestration that were demonstrated by this project to showcase how crop production could be intensified sustainably while also ensuring food security.

(c) **CSA technical guidelines for two staple crop production systems**. Based on the verified results of the project-promoted CSA techniques in the two project counties, two national technical guidelines were developed. These guidelines provided specific technical principles on how to carry out climate smart production for wheat-corn and wheat-rice cropping systems. They will be officially adopted by MARA in 2021 for CSA good practices. Two other guidelines on CSA production technologies and monitoring, verification, and reporting (MVR) were developed.

(d) **A Baseline and Monitoring Methodology for Quantification of GHG mitigation** associated with implementing CSA technologies and practices in staple crop production in China's context. This methodology has been reviewed by MARA expert panel and is scheduled to be approved by MARA in 2021. It will promote domestic carbon offset projects that implement CSA technologies in staple crop production and facilitate the scale-up of mitigation actions in China's staple crop production systems with CSA technologies and practices.

57. More CSA related policies and plans are expected to be rolled out by MARA in the next a few years, partly influenced by the project. Scaling up these demonstrated best practices and technologies to other parts of China will help reduce China's greenhouse gas emissions from agricultural sector and help achieve China's Nationally Determined Contribution to climate change.

58. The project also supported capacity-building and awareness-raising of CSA by distributing newsletters and promotional materials to disseminate progress and results of the project implementation, and successful experiences and lessons learned under this project. In the two project provinces, dissemination activities were organized to educate farmers and extension service technicians from non-project townships surrounding the project areas, to other areas the two provinces. Good practices generated by the project have been disseminated nationally through the MARA network.

59. The project also promoted international CSA cooperation through an international forum that was jointly organized by MARA and the World Bank in September 2020. The forum provided a platform to share the experiences and valuable lessons learned from using CSA technologies and practices under the project and best practices that would make Chinese agriculture more resilient to climate change and mitigate its negative impacts on the global climate. Both Chinese and international audiences participated.

Mobilizing Private Sector Financing

60. The project was not designed to mobilize private sector financing.

Poverty Reduction and Shared Prosperity

61. Although the project focused on providing public goods (climate benefits), it contributed positively to poverty reduction and shared prosperity by enhancing crop yields and reducing production inputs. According to the 2013 official statistics, about 12 percent of the project targeted households were living below the national poverty line (extreme poverty) at project appraisal. Project interventions effectively reduced GHG emissions and increased carbon sequestration, and reduced farming costs, increased yields, and farmers' net incomes. By the end of 2020, all targeted households were officially declared out of extreme poverty by the county governments.

III. KEY FACTORS THAT AFFECTED IMPLEMENTATION AND OUTCOME

A. KEY FACTORS DURING PREPARATION

62. **The project was well-prepared with realistic and specific objectives measured by a well-reasoned Results Framework.** The PDOs were clearly defined with outcome/intermediate outcome indicators. The components complemented each other and contributed to the PDOs. The interventions bore a direct causal relationship to intermediate and PDO indicators, making the Theory of Change (TOC) well-founded with clear operational logic. The selection of project provinces/counties was appropriate in terms of agronomic conditions and targeted beneficiaries. The risk that implementing agencies would be unfamiliar with Bank operational policies and regulations was clearly identified and needed capacity strengthening was subsequently implemented.

63. **The implementation management structure was designed properly with responsibilities clearly stated for the project management offices at the central, provincial, and county levels (See Section III.B).** Furthermore, MARA prepared a Project Implementation Manual (PIM) before project approval to guide project implementation. The Manual provided detailed information on: (a) the project objectives, activities and financing arrangements; (b) roles and responsibilities of the national PMO, provincial PMOs, county Project Management Units (PMUs) and other entities involved in project implementation; (c) financial management, disbursement, procurement, and safeguards arrangements; (d) steps and procedures for project implementation; and (e) monitoring and evaluation, reporting and information disclosure arrangements.

64. **Project M&E was well-designed with solid work done in advance on baseline surveys, sound monitoring methodologies and realistic measures for data collection.** Detailed production baselines of the rice-wheat cropping system in Huaiyuan County (Anhui Province) and the wheat-corn cropping system in Yexian County (Henan Province) were done during project preparation (See Section IV.A).

65. **The project was well-structured with substantive components complemented by institutional capacity enhancement and policy advice.** Good practices and knowledge generated by the CSA demonstration component contributed to policy measures developed under Component 2, which promoted long-term sustainability of project interventions. Farmer’s field schools supported by the project played an important role in scaling up the CSA demonstration within and beyond the project areas.

B. KEY FACTORS DURING IMPLEMENTATION

66. **Well-established institutional arrangements were instrumental to successful project implementation. At the central level, a National Project Steering Committee (NPSC) led by MARA with the participation of key national stakeholders guided the overall implementation of the project.** The National Project Director (NPD) of the Project Management Office (PMO) at MARA managed project implementation with technical support from a National Expert Group (NEG). At the provincial level, a Provincial Leading Group (PLG) led by the Department of Agriculture (DOA) of each of the two project provinces oversaw project implementation in the respective province with support from a Project Management Unit hosted in the DOA. At the county level, a County Leading Group (CLG) led by a deputy head of the county government guided project implementation with the support of the county Project Management Unit (PMU) hosted by the Agriculture Bureaus of the respective county. This three-level project management mechanism coordinated and operationalized the project activities well.

67. **Effective application and improvement of the M&E Methodologies contributed to the achievement and verification of the project outcomes (Section IV.A).**

68. **However, implementation delays occurred in the first year due to the slow process of signing the grant transfer agreement between the Ministry of Finance and the Ministry of Agriculture at the central level.** Although the project was launched on September 19, 2014, 10 days prior to the Grant Agreement was signed by the Government of China (GOC) and the World Bank, the Grant Transfer Agreement between the Ministry of Finance (MOF) and Ministry of Agriculture was not signed until March 6, 2015. This resulted in project implementation missing the winter wheat season.

69. **Project implementation progress was hampered by the COVID-19 pandemic in 2020.** Some project activities, including training and capacity building, field monitoring of the project outputs and safeguards compliance, and procurement of critical contracts were delayed at the very late stage of project implementation, posing a risk to closing the project on September 30, 2020. However, with the unremitting efforts by PMOs, all the planned activities, including the key Climate Smart Agriculture International Forum event, were completed on time.

70. **The Bank team provided adequate project supervision and implementation support and were responsive to evolving technical demands.** The Bank set up a multi-disciplinary team of senior staff and consultants, to supervise the project and provide quality implementation support and practical training on technical, procurement, financial management, safeguards and project management. The mid-term review (MTR) mission and project restructuring were conducted on time with a well-prepared report from the client confirming good progress (See Section IV.C).

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

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

M&E Design

71. **The M&E system design had a clear Results Framework (RF) and adequate indicators.** The project's RF was well prepared with Specific, Measurable, Attainable, Relevant, and Time-Bound (SMART) outcome/intermediate outcome indicators. The interventions under various components complemented each other and contributed to achieving the PDOs. Further, the interventions bore direct causal relation to intermediate and PDO indicators, making the theory of change well founded with a clear operational logic (See Section I.A).

72. **Sound methodologies for GHG emissions reduction quantification.** The methodologies were appropriate at the appraisal. Considering the project's objectives, it used the right approach for the GHG emissions calculations by selecting internationally and nationally approved methodologies. The project document indicated the following methodologies were used to calculate GHG emissions and removals: (a) Clean Development Mechanism approved methodology: AMS-III.AU- Methane Emission Reduction by Adjusted Water Management Practice in Rice Cultivation - Version 3.0 (for quantifying methane emissions from rice); (b) Verified Carbon Standard approved methodologies: VM0021: Soil Carbon Quantification Methodology, Version 1.0 (for quantifying soil carbon sequestration); and VM0022: Quantifying N2O Emissions Reductions in Agricultural Crops Nitrogen Fertilizer Rate Reduction – Version 1.0 (for quantifying emissions from fertilizer use); VM0026: Methodology for

Sustainable Grassland Management, Version 1.0 (for quantifying emissions from biomass burning); and (c) China NDRC approved methodology: Forest Management Carbon Sink Project Methodology, Version 01 (for quantifying GHG removeal by sinks from agroforestry). The project appraisal document also indicated that in addition to these methodologies, the 2006 Guidelines for National GHG Inventories of the Intergovernmental Panel on Climate Change (Volume 4: Agriculture, Forestry, and Other Land Use) and models (e.g., DeNitrification-DeComposition Model, RothC/Century Model) could be adopted in the project context as relevant.

73. **Another salient feature of the M&E design was establishing the baseline during project preparation,** which followed the methodologies and guidance approved under the United Nations Framework Convention on Climate Change. Stratification of the baseline values was done, and baseline strata were identified based on the cropping system, farm type and soil type, laying a solid foundation to evaluate results/performance, and the cost-effectiveness of various CSA technical options.

M&E Implementation

74. **Effective application and improvement of the methodologies during the project implementation[9].** During the first two years of implementation, the M&E team analyzed direct measurements of GHG emissions (N_2O, CO_2 and CH_4), using static chamber gas chromatography, soil organic carbon through carbon combustion analyzer, and forest carbon sequestration by measuring diameter at breast height (DBH) or average height and the number of trees. The monitoring team undertook stratified sampling for two years to tackle the spatial variability and obtain accurate results (2015-2017). The stratification took into account the following variables: type of cropping system (rice, wheat, corn, farm forestry); soil type and property (soil texture, pH, organic matter, etc.); farm type (large-scale household/commercial, family/subsistence; and management (fertilizer, water, and straw, etc.). The sampling and verification process benefited from the best global practices shared by a top international expert recruited by the Bank. Collaboration with universities and research institutions for GHG emissions and soil carbon content monitoring leveraged local knowledge and contributed positively to the quality of the analysis and improved the national capacity for these methodologies.

75. The DeNitrification-DeComposition (DNDC) model was verified and calibrated by two years of observation data (four cropping seasons), showing a general convergence of modeling results with field observations. Thereafter, the team used a modeling approach to calculate emissions; that was also cost-effective by reducing field measurement and labor requirements. Based on this, a monitoring methodology for quantifying GHG mitigation for CSA technologies and practices in staple crop production was developed. This methodology has been reviewed by the MARA expert panel and is scheduled to be approved by MARA by the end of 2021 for nationwide adoption. Recent literature suggests the DNDC model is sensitive to rainfall, soil organic carbon and temperature which can result in overestimation of N_2O peaks during the warm wet season. Therefore, the modeling could have further benefited from a subset of direct validation analysis after the first two years.

76. **The M&E data were collected and analyzed in line with methodologically sound design by an independent third-party agency.** Against the baseline values, greenhouse gas (GHG) emissions reduction and carbon sequestration were broken down by types of activities, crops, and counties. Relevant mitigation measures specified in the Environmental Codes of Practice (ECOP) and Pest Management Plan (PMP) were also closely monitored by the agency for each province.

[9] See Annex 8: Climate Smart Crop Production System Carbon Sequestration and Emission Reduction Monitoring

M&E Utilization

77. **The M&E data analyses were used to inform project management and develop technical norms/standards.** The critical data and analyses were provided for implementation progress evaluation, project restructuring and implementation completion and result report (ICRR). The M&E system, as designed and implemented, was practical and adequate to assess how well GHG emissions reduction, carbon sink and crop yield objectives were achieved. The government has recommended adopting the same approaches for future projects.

Justification of Overall Rating of Quality of M&E

78. The overall quality of M&E was rated as ***Substantial, based on the above assessment.***

B. ENVIRONMENTAL, SOCIAL, AND FIDUCIARY COMPLIANCE

Environmental and Social Safeguards Compliance

79. The project generated positive environmental impacts in terms of reducing GHG emissions, overuse of agricultural inputs and their release into the environment and improving soil organic carbon contents. The proposed project investments triggered three safeguards: Involuntary Resettlement (OP 4.12), Environmental Assessment (OP4.01) and Pest Management (OP4.09). The project complied with all safeguards policies and safeguards performance was satisfactory, as elaborated below.

80. **Involuntary Resettlement (OP 4.12).** The Bank's OP 4.12 Involuntary Resettlement was triggered as the project's counterpart funding financed the construction/rehabilitation of on-farm crops production infrastructure such as farm roads or irrigation canals that involved small-scaled land acquisition activities. During the project's preparation, MARA's consultant prepared a Resettlement Policy Framework (RPF) for the entire project with: (a) detailed procedures on preparation, review and approval of potential land acquisition activities; (b) institutional and financial arrangements for carrying out such activities; and (c) the monitoring plan for supervising the implementation of such activities. The RPF, agreed between the Bank and MARA, was disclosed locally in the two project counties on April 24, 2014 and the World Bank's InfoShop on May 8, 2014. The agreed RPF under this project was satisfactorily implemented by PMOs.

81. **Environmental Assessment (OP4.01).** The project was classified as Category B – partial assessment. The construction and rehabilitation of small scale on-farm agricultural infrastructures (such as irrigation canals and improving existing farm roads) under Component 1 generated some environmental impacts (noise, air, wastewater, solid waste, etc.) which were short-term, temporary, limited and local in nature, and were readily managed with cost-effective mitigation measures during project implementation. Environmental Codes of Practice (ECOPs) were prepared for such investment in accordance with the Bank environmental safeguard requirements. ECOPs implementation was deemed generally satisfactory based on the review and monitoring and mission field visits by PMOs and the Bank's task teams.

82. **Pest Management (OP4.09).** The project promoted Integrated Pest Management (IPM) practices and supported the review and development of technical codes and standards related to applying agricultural inputs (including

pesticides) in CSA practices. A Pest Management Plan (PMP) was prepared for rice, wheat and corn production at the project sites and its implementation was generally satisfactory throughout the project. The impacts were environmentally positive as the project reduced the use of pesticides and fertilizers.

83. **Public Consultation and Disclosure.** In accordance with the Bank's safeguards policies and Chinese EA regulations, public consultations were conducted with project farmers and other stakeholders through meetings and on-site surveys and interviews during the project preparation. The opinions and concerns of the people consulted were considered in the safeguards' documents and the project design. The project information was disclosed at project villages and government websites. Given the Bank's information disclosure policy, on April 24, 2014 the ECOPs and PMP were made available in the project areas, on the websites of MARA and the local agricultural bureaus and were accessible at national and provincial PMOs. The ECOPs, PMP were first disclosed at the World Bank InfoShop on May 8, 2014. Final versions of ECOPs and PMP were disclosed at the World Bank InfoShop on May 26, 2014.

Fiduciary Compliance

84. **Financial Management (FM).** The Ministry of Finance (MOF) managed the GEF grant, including overseeing the Designated Account before government institutional reform; after that the DA was moved to MARA. The changes of financial staff at both national and county levels and the complex disbursement review process made disbursement inefficient in the first two to three years during project implementation, resulting in late submission of the interim financial reports. The required annual audit reports were submitted timely, and the external auditors issued unqualified audit opinions during project implementation. The Bank team provided FM-related implementation support and on-the-job training to relevant financial staff at PMOs to ensure that an acceptable financial management system was in place.

85. **Procurement.** The MARA PMO, in line with the legal covenants and the Bank's procurement guidelines, carried out procurement activities with designated staff attended procurement training provided by the Bank team during project preparation, and additional trainings during project implementation. During implementation, the MARA PMO arranged continuous capacity-building events on procurement and contract management for staff members of the PMO and two county PMUs. The procurement plan for project implementation was agreed upon during project negotiations and was regularly updated thereafter. The Bank team closely oversaw procurement activities carried out by the client and advised on procurement-related issues raised by the PMO. The Bank team also provided procurement-related implementation support and on-the-job training to relevant procurement staff to ensure compliance with Bank procurement policies and procedures. The overall procurement management performance throughout implementation was Satisfactory.

C. BANK PERFORMANCE

Quality at Entry

86. The Bank's performance at entry was satisfactory. The Bank team, composed of senior staff with rich country and technical experience, worked closely with the client during the preparation process to ensure:
    (a) Project's high relevance to China's national development strategies (see Section II.A).
    (b) Well-structured project design integrating technical interventions with capacity building and formation of policy advice (See Section III.A).
    (c) CSA technique pilots well selected and sequenced with relatively mature technologies demonstrated at

a large scale and newer technologies first at a small scale and then scaled up selectively based on actual pilot results.

(d) Effective M&E design and arrangements. The comprehensive baseline survey during project preparation laid a solid foundation to gauge the project impact rigorously (See Section IV.A). Incorporating the M&E directly into the CSA component set a good example to ensure that M&E was implemented and used simultaneously with physical progress reports.

(e) Adequate risk management plan that identified the weaknesses in implementation capacity with mitigation measures put in place.

(f) Bank's inputs were appropriate and reasonable, and the preparation process was efficient, as shown by the relatively low preparation costs (see annex 2) and 12-month preparation time which is much shorter than the average for China (18 months).

(g) Environmental, social and fiduciary aspects were well covered in the project design (See Section IV.B) and were also specified in the Project Implementation Manual (PIM), prepared by the client.

Quality of Supervision

87. **The Bank's performance during supervision was satisfactory.** The Bank provided adequate staff and resources for project implementation support. Project restructuring was conducted in good time to extend the project to cover the full crop production season and to pilot new CSA technologies, which required adequate time for collecting and assessing the results (See Section I.B). During the late months of implementation under COVID-19 travel restrictions, virtual supervision missions and consultations were organized in a timely way to address the potential delay of the key project activities (See Section III.B). The Bank team also provided sufficient technical and implementation support and conducted trainings to enhance the institutional capacities in fiduciary, environmental and social safeguards management (See Section IV.B). In particular, recruiting an internationally recognized soil scientist before the MTR mission provided best advice to the PMOs and the monitoring team to ensure the soundness of M&E work for GHG emission reduction and soil carbon sequestration.

88. Bank missions were regular, candid, and timely in reporting progress and highlighting issues, and proposed practical follow-up actions in mission Aide Memoires, Management Letters, and Implementation Status and Results Reports. The task team, composed of experienced professionals, were responsive to the PMO's requests and the technical recommendations provided were appropriate and practical. Safeguard policy compliance and fiduciary management were well covered during implementation support missions (See Section IV.B). The cordial and close rapport that was developed between the Bank teams and the client was recognized in the government ICR. The TTL turnover (three TTLs during project implementation) was smoothly handled by senior professional Bank staff, all with rich experience in China, which avoided the potential negative impact of TTL transition.

Justification of Overall Rating of Bank Performance

89. **The overall Bank performance was rated as *Satisfactory*,** which was confirmed by the counterpart in its ICR.

D. RISK TO DEVELOPMENT OUTCOME

90. The risk to development outcome is assessed as below:
    (a) For project interventions that were financially profitable (without subsidies), such as IPM vis-à-vis reduced pesticide use and water-saving irrigation practices, farmers continuously adopted them on their own; while the government would continue making well-targeted subsidies for interventions that were not profitable to farmers. Central and provincial governments adopted nationwide subsidies for straw-returning mechanization, green manure and pollution control to support implementation of CSA activities. Subsidies also covered applying organic fertilizer instead of chemical fertilizer for fruit, vegetables and tea, green fertilizer from rotation and fallow cultivation, and formula fertilizer. A special fund for agro-ecological protection and resource utilization was established in 2019. Notably the full benefits of some CSA technologies (e.g. conservation tillage, use of organic manure) occur over the medium term, as shown by experiences in other countries. As farmers gain more experience with using CSA, and the full benefits of using the package of CSA technologies materialize over the medium term, there is potential for the subsidy packages to be adjusted.
    (b) The CSA strategies and technical packages developed under the project were mainstreamed into the national government policies and development programs, as part of the government's obligations to Nationally Appropriate Mitigation Actions in the agriculture sector, thus ensuring that the project demonstrated good practices were scaled-up nationwide.
    (c) As the first CSA cooperation between the Bank and MARA , the project's lessons and experiences have been transferred to other Bank-financed projects in China, including the Henan Green Agriculture Fund Project (approved in March 2020) and Hubei Smart and Sustainable Agriculture Project (approved in May 2020), which both aim to promote integrated environmentally sustainable and climate-smart agriculture, and agri-food quality and safety, in targeted value chains and landscapes in Henan and Hubei Provinces.
    (d) The good practices and knowledge products of this project were incorporated into the design of the Global Environment Facility (GEF-7) - Food Systems, Land Use and Restoration (FOLUR) Impact Program (IP) and FOLUR IP Global Platform. MARA is an Implementing Agency for the new FOLUR China child project covering the same staple food such as wheat, corn, and rice in the provinces of Jiangxi, Jiangsu, Shandong, and Guizhou, thus offering a great opportunity to share and scale-up knowledge generated from the project.

V. LESSONS AND RECOMMENDATIONS

91. The project generated the following lessons and recommendations, which are generally applicable to similar operations of climate smart staple crop development in China and other countries in the following thematic areas:

On Project Design and M&E

92. **Well-structured project design with a two-pronged approach for demonstrating good practices and formulating policy advice ensured project sustainability**. The good practices and knowledge in GHG emissions reduction and carbon sequestration generated by the project interventions were supported by enhancing institutional capacity and directly contributing to the policy measures developed under Component 2, which in turn, promoted long-term sustainability and replicability of project interventions (See Section III.A).
93. Well-designed project institutional arrangement was instrumental to successful project implementation. The

project management mechanism did a good job of coordinating and operationalizing project activities. It facilitated the replicability of CSA technologies and GAPs in both project provinces and nationwide (See Section III.B.). This broader influence and scalability would not have been possible if the project was only implemented locally.

94. **A sound project monitoring and evaluation system with a solid baseline survey was essential to efficient project implementation.** The M&E system design had a clear Results Framework and adequate indicators, with a technically sound baseline survey done at project preparation on the cropping system, farm type and soil type, laying a solid foundation for evaluating results, performances, and the cost-effectiveness of various CSA technical options. Further, M&E data were collected and analyzed by a professional third-party agency, which ensured the independence of the M&E process and data quality (See Section IV.A).

On CSA Policy Formulation

95. **The CSA interventions of a public good nature need support through a government PES or similar program**. The compensations provided to the farmers were well founded and were effective means to achieving much more valuable climate benefits. As demonstrated in the economic analysis, in terms of the cost benefit ratio, the subsidies for farmers could generate far more climate benefits. The public good delivery by farmers should be fully recognized and compensated fairly, as the beneficial externalities generated by a farmer cannot be internalized (See Section II.C). As such, it would be desirable if compensation for CSA technologies could be covered in the PES program.

96. **The magnitude/level of CSA compensations should be based on crop/activity specific implementation results to enable efficient and effective use of public financing**. As different technical interventions generated divergent financial returns for farmers and economic returns for society as a whole, the compensations should target and focus on those generating more public good (See Section II.C).

On farmers centered extension/outreach activities

97. **Farmers' roles and participation in the demonstration process, and the subsequent social and economic impacts on farmers are key to behavioral change, CSA technology adoption and upscaling**. For farmers, CSA interventions should simultaneously address the interlinked challenges of agricultural productivity/food security and climate change, with financial incentives from government compensations to ensure the project sustainability (see Annex 7).

ANNEX 1. RESULTS FRAMEWORK AND KEY OUTPUTS

A. RESULTS INDICATORS

A.1 PDO Indicators

Objective/Outcome: Demonstrate climate smart and sustainable staple crop production

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Reduced GHG Emission (CO2 equivalent)	Metric ton	0.00 01-Sep-2014	21000.00 31-Mar-2020	21,000.00 30-Sep-2020	29,782.00 30-Sep-2020

Comments (achievements against targets):
The original target was achieved, exceeding the original target by 41.8 percent. The cumulative GHG emissions reduction was achieved through methane emissions reduction due to improved water management (financed by the government's counterpart funding in the rice fields), and nitrous oxide emissions reduction predominantly through improved use of inputs production. Annex 8 presents the detailed methodology.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Increase in Carbon Sequestration (CO2 equivalent)	Metric ton	0.00 01-Sep-2014	44000.00 31-Mar-2020	44,000.00 30-Sep-2020	99,565.00 30-Sep-2020

Comments (achievements against targets):

The original target was achieved, exceeding the original target by 126 percent. Soil organic carbon was monitored using direct field sampling with a subsequent combustion method. The achievement was mainly due to the higher than expected crop residue retention combined with improved soil water content and soil structure.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Change in average crop yield	Percentage	0.00 01-Sep-2014	8.00 31-Mar-2020	8.00 30-Sep-2020	8.02 30-Sep-2020

Comments (achievements against targets):
The original target was achieved.

A.2 Intermediate Results Indicators

Component: CSA Demonstration

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Crop production areas adopted project promoted practices	Hectare(Ha)	0.00 01-Sep-2014	4000.00 31-Mar-2020	4,000.00 30-Sep-2020	6,700.00 30-Sep-2020

Comments (achievements against targets):

The original target was achieved, exceeding the original target by nearly 68 percent.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Reduction in inputs - fertilizer (Ton)	Text	0.00 01-Sep-2014	500 31-Mar-2020	500.00 30-Sep-2020	572.00 30-Sep-2020

Comments (achievements against targets):
The original target was achieved, exceeding the original target by 14 percent.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Reduction in inputs - Pesticide (Kg)	Text	0.00 01-Sep-2014	100 31-Mar-2020	100.00 30-Sep-2020	121.00 30-Sep-2020

Comments (achievements against targets):
The original target was achieved, exceeding the original target by 21 percent.

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

Reduction in inputs - water	Cubic Meter(m3)	0.00 01-Sep-2014	1000000.00 31-Mar-2020	1,000,000.00 30-Sep-2020	1,450,000.00 30-Sep-2020

Comments (achievements against targets):
The original target was achieved, exceeding the original target by 45 percent.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Area serviced by professional service providers with new CSA techniques	Hectare(Ha)	0.00 01-Sep-2014	3000.00 31-Mar-2020	3,000.00 30-Sep-2020	3,350.00 30-Sep-2020

Comments (achievements against targets):
The original target was achieved, exceeding the original target by 12 percent.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Number of farmer field schools under proper operation	Number	0.00 01-Sep-2014	30.00 31-Mar-2020	30.00 30-Sep-2020	30.00 30-Sep-2020

Comments (achievements against targets):

The original target was achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Change in average net staple crop production income	Percentage	0.00 01-Sep-2014	12.00 31-Mar-2020	12.00 30-Sep-2020	14.20 30-Sep-2020

Comments (achievements against targets):
The original target was achieved, exceeding the original target by 18 percent.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Clients who have adopted an improved agr. technology promoted by the project	Number	0.00 01-Sep-2014	25000.00 31-Mar-2020	25,000.00 30-Sep-2020	28,474.00 30-Sep-2020
Clients who adopted an improved agr. technology promoted by project – female	Number	0.00 01-Sep-2014	12000.00 31-Mar-2020	12,000.00 30-Sep-2020	12,050.00 30-Sep-2020

Comments (achievements against targets):
The original target was achieved, exceeding the original target by 14 percent.

Component: Policy Development and Knowledge Management

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Policy documents developed	Number	0.00 01-Sep-2014	5.00 31-Mar-2020	5.00 30-Sep-2020	5.00 30-Sep-2020

Comments (achievements against targets):
The original target was achieved.

Component: Project Management

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Client days of training provided (person*day)	Number	0.00 01-Sep-2014	25000.00 31-Mar-2020	25,000.00 30-Sep-2020	25,016.00 30-Sep-2020
Client days of training provided - Female (person*day)	Number	0.00 01-Sep-2014	14000.00 31-Mar-2020	14,000.00 30-Sep-2020	11,050.00 30-Sep-2020

Comments (achievements against targets):
The original target was achieved.

B. KEY OUTPUTS BY COMPONENT

Objective/Outcome 1: to reduce GHG Emission	
Outcome Indicators	Amount of Reduced GHG Emission (CO_2 equivalent)
Intermediate Results Indicators	1. Crop production areas adopted project promoted practices 2. Reduction in inputs - fertilizer (Ton) 3. Reduction in inputs - Pesticide (Kg) 4. Reduction in inputs – water
Key Outputs by Component (linked to the achievement of the Objective/Outcome 1)	Intermediate Results Indicators are output indicators. For example, by project closing, “Reduction in inputs” was 572 ton for fertilizers, 121 kilograms for pesticides, and 1.45 million M^3 for water.
Objective/Outcome 2 to increase Carbon Sequestration	
Outcome Indicators	Amount of increased carbon sequestration (CO_2 equivalent)
Intermediate Results Indicators	1. Crop production areas adopted project promoted practices 2. Clients who have adopted an improved agricultural technology promoted by the project
Key Outputs by Component (linked to the achievement of the Objective/Outcome 2)	Intermediate Results Indicators are output indicators. For example, by project closing, “Crop production areas adopted project promoted practices”, e.g., conservation agriculture, no-till/low tillage, and crop straw returning to soil, were 6,700 ha; “Clients who have adopted an improved agricultural technology promoted by the project” were 28,474.
Objective/Outcome 3: to increase crop yield	
Outcome Indicators	Crop yield increase (percent)
Intermediate Results Indicators	1. Crop production areas adopted project promoted practices 2.Number of farmer field schools under proper operation 3.Change in average net staple crop production income 3. Clients who have adopted an improved agr. technology promoted by the project

Key Outputs by Component (linked to the achievement of the Objective/Outcome 1)	Intermediate Results Indicators are output indicators. For example, by project closing, “Number of farmer field schools under proper operation” were 30 and “Change in average net staple crop production income” was 14.2 percent.

ANNEX 2. BANK LENDING AND IMPLEMENTATION SUPPORT/SUPERVISION

A. TASK TEAM MEMBERS

Name	Role
Preparation	
Jiang Ru	Task Team Leader(s)
Yuan Wang	Procurement Specialist(s)
Songling Yao	Social Specialist
Yiren Feng	Environmental Specialist
Ademola Braimoh	Sr Natural Resources Mgmt. Spec.
Wendao Cao	Senior Rural Development Specialist
Junxue Chu	Senior Finance Officer
Yi Dong	Sr Financial Management Specialist
Minneh Mary Kane	Lead Counsel
Bernardita Ledesma	Operations Analyst
Zijing Niu	Program Assistant
Aristeidis I. Panou	Consultant
Rama Chandra Reddy	Senior Carbon Finance Specialist
Yunqing Tian	Team Assistant
Zhihong Zhang	Senior Program Officer
Supervision/ICR	
Jianwen Liu, Ladisy Komba Chengula	Task Team Leader(s)
Yuan Wang	Procurement Specialist(s)
Yi Dong	Financial Management Specialist
Yan Zhang	Procurement Team

Xuan Peng	Sr. Program Assistant
Tam Thi Do	Program Assistant
Aimin Hao	Social Specialist
Xueming Liu	Senior Economist-FAO/CP, ICR lead author
Armine Juergenliemk	Team Member, ICR co-author
Bin Xu	Environmental 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	1.550	26,312.79
FY14	31.696	180,856.29
FY15	4.545	27,396.85
FY16	0	-1,016.28
Total	**37.79**	**233,549.65**
Supervision/ICR		
FY15	1.512	14,563.47
FY16	1.150	13,922.74
FY17	6.100	27,799.28
FY18	2.850	45,147.88
FY19	.950	12,704.42
FY20	1.941	17,970.66
Total	**14.50**	**132,108.45**

ANNEX 3. PROJECT COST BY COMPONENT

Table 1. Project Cost by Component

Components	Amount at Approval (US$M)	Actual at Project Closing (US$M)	Percentage of Approval (US$M)
CSA Demonstration	23.96	27.02	113 percent
Policy Development and Knowledge Management	3.90	4.21	108 percent
Project Management	2.24	2.26	101 percent
Total	**30.10**	**33.50**	**111 percent**

Table 2: Project Cost by Financer at Appraisal

Components	GEF Financing (US$M)	Gov. Financing (US$M)	Total (US$M)
CSA Demonstration	3.96	20.00	23.96
Policy Development and Knowledge Management	0.90	3.00	3.90
Project Management	0.24	2.00	2.24
Total	**5.10**	**25.00**	**30.10**

Table 3: Project Cost by Financer at ICR

Components	GEF Financing (US$M)	Gov. Financing (US$M)	Total (US$M)
CSA Demonstration	3.96	23.06	27.02
Policy Development and Knowledge Management	0.90	3.31	4.21
Project Management	0.24	2.02	2.26
Total	**5.10**	**28.40**	**33.50**

ANNEX 4. EFFICIENCY ANALYSIS

1. Following the approach adopted at appraisal, cost-benefit analysis was conducted to re-assess the project's ex-post economic viability at completion. The analysis was performed at the project level for the aggregated interventions, using the "with/without project" comparison methodology. The incremental economic costs include: (a) investment for new technologies adoption; (b) operational costs for agricultural production; and (c) project management and capacity-building costs. The major benefits included in the analysis are: (a) incremental agricultural production, (b) savings from reduced agricultural input costs, including fertilizer, agrochemicals, diesel and irrigation water; and (c) environmental benefits from GHG emissions reduction.

2. The financial analysis at the farmer level, only accounted for the impact of the project activity on the actual income and expenditure of the farmer. Climate benefits from the project and other positive externalities (e.g. reduced pollution of air, water, or soil) were not accounted for in this farmer-level financial analysis.

3. The economic benefits and cost of the project's major technical interventions are summarized in Tables A4.1 and 4.2. The following assumptions apply for the all project interventions: (a) economic value for carbon pricing with a high and low case scenario following the guidelines of the World Bank: "Guidance note on the shadow price of the carbon in the economic analysis" (September 2017)10; (b) project life of 20 years; (c) social discount rate at 12 percent; and (d) no adjustment between financial and economic prices per recent Bank project analysis (Table 4.3). The results of the economic analysis for the five activity modules and each county as a whole are shown in Tables A4.4 and A4.5.

4. The financial benefits of the project are analyzed based on the incremental benefits and incremental costs of the project from the perspective of farmers. The financial benefits of each sub-project in the two project counties are shown in the "Income Changes", "Change in operating costs" and "Fixed investment" columns in Tables A5.1 and A5.2. The environmental benefits of the project are not included in the calculation of financial benefits. To examine the impact of the financial subsidy policy on farmers, the financial internal rate of return (FIRR) of each project activity is measured both with and without financial subsidies. Tables A 4.6 and A 4.7 show the results of the financial analysis for the two project counties, with and without subsidies for farmers.

5. The analysis concluded that, without government subsidies, some project interventions, such as IPM (pest management, with reduced pesticide use) and water-saving irrigation practices, were financially viable with financial internal rate of returns (FIRRs) all above the financial discount rate of 12 percent, as adopted by key commercial Banks in China to assess financial viability. For those activities, an initial subsidy is justified to incentivize farmers to try the new technical packages, but once they are proven to be financially profitable, farmers will continue to use them even without subsidies. Yet without subsidies, other project interventions such as conservation tillage and mechanized crop residue retention in field are not financially viable, as they mainly generate positive externalities (carbon sequestration and GHG emissions reduction) that cannot be internalized by farmers. As such, project subsidies for those activities should be continued and even increased to ensure their sustainability and scale-up, considering thepublic goods generation potential in terms of climate and ecosystem services co-benefits. Therefore, realigning agricultural support to promote CSA, including payments for carbon sequestration and ecosystem services, provides an untapped opportunity to deliver public goods and improve the rural livelihoods.

[10] https://documents.worldbank.org/en/publication/documents-reports/documentdetail/621721519940107694/guidance-note-on-shadow-price-of-carbon-in-economic-analysis

6. Table A4.8. summarizes the EIRRs and FIRRs to farmers without subsidies for the eight modules of the project. The table shows that the project interventions are economically viable with higher CO2 pricing, and EIRRs of all modules are higher than the corresponding FIRRs in the "without subsidy scenario", indicating externality benefits accrued to society as whole instead of farmers.

7. The "subsidies" provided to the farmers are all well founded and are an effective means to achieving much more valuable climate benefits. As shown in the analysis, subsidies to farmers can generate far more climate benefits. The public good delivery by farmers therefore should be fully recognized and compensated fairly, as the positive externalities generated by farmers cannot be internalized by them.

8. Government subsidies should be well targeted based on specific crops and activity, using specific and actual implementation results to enable efficient and effective use of public financing. As different technical interventions generate different financial returns for farmers and economic returns for society as a whole, the subsidies should target and focus on those generating the greatest public good.

Table A 4.1: Economic costs and benefits – Huaiyuan County

Main activities	Environmental benefits (GHG reduction)	Income changes	Changes in operating costs	Fixed Investment
Demonstration and application of fertilizer reduction	• GHG emissions reduction converted from fertilizer reduction, reduced soil and water pollution	• Rice yield increased by 53 kg/mu • Wheat yield increased by 35 kg/mu	• Soil testing formula fertilization is 115 CNY/mu per year cheaper than conventional chemical fertilizer • Mechanized operation cost increase of 60 CNY/mu per year.	• Fertilizer distributor, fertilizer spinner, top dressing machinery, etc. • Collection of soil samples for testing
Pesticide application reduction and integrated pest management technology	• GHG emissions reduction converted from pesticide reduction, reduced pollution and negative impacts on biodiversity	• None	• Rice – "one spray three prevention" service cost is cheaper than conventional pesticides 90 CNY/mu • Wheat – "one spray three prevention" service costs more than conventional pesticides 32 CNY/mu	• Sprayers
Demonstration and application of water saving irrigation technology	• GHG emissions reduction from the reduced of irrigation energy use,	• Rice yield increased by 40 kg/mu • Wheat yield increased by 20 kg/mu	• Rice irrigation water consumption savings of 38 percent (115 m^3/mu) • Wheat irrigation water consumption savings of 50 percent (20 m^3/mu)	• Investments that are directly related to the objectives of the module activities, include: • Well-established water-saving irrigation system. • High-standard farmland construction and renovation.
Demonstration and application of mechanized straw returning to field and conservation tillage carbon for sequestration technology	• GHG emissions reduction converted from mechanized straw returning to field	• Rice yield increased by 27 kg/mu • Wheat yield increased by 10 kg/mu	• The operating cost of mechanized rice straw returning to the field is 15 CNY/mu less than the costs of comprehensive use and collection. • The operating cost of mechanized wheat straw return to the field is 50 CNY/mu less than the cost of comprehensive utilization and collection.	• Crushing rotary tiller

Table A 4.2: Economic costs and benefits - Yexian County

Project intervention	Environmental benefits (GHG emissions emission reduction)	Income changes	Changes in operating costs	Fixed Investment
Demonstration and application of fertilizer reduction technology	• GHG emissions reduction converted from fertilizer reduction	• Maize yield increased by 60 kg/mu • Wheat yield increased by 50 kg/mu	• Soil testing formula fertilization is 155 CNY/mu per year cheaper than conventional chemical fertilizer • Mechanized operation cost increased by 80 CNY/mu per year	• Fertilizer distributor, fertilizer spinner, top dressing machinery, etc. • Collection of soil samples for laboratory testing
Demonstration and application of optimized irrigation technology	• GHG emissions reduction from optimization and reduction of irrigation	• Corn yield increased by 30 kg/mu • Wheat yield increased by 40 kg/mu	• Corn irrigation water consumption savings of 12.5 percent (10 m3/mu); • Wheat irrigation water consumption savings of 33.33 percent (20 m3/mu)	• Field supporting works (facilities); transformer
Demonstration and application of mechanized straw returning to field and conservation tillage carbon sequestration technology	• GHG emissions converted from mechanized straw returning to field	• Maize yield increased by 20 kg/mu • Wheat yield increased by 10 kg/mu • In the project state, the straw can no longer be used as fuel or feed and is no longer available for sale.	• The operation cost of mechanized corn straw return to the field saves 50 CNY/mu compared to comprehensive use and collection costs. • The operation cost of mechanized wheat straw return to the field saves 25 CNY/mu compared to the comprehensive use and collection costs.	• Corn combine harvester, wheeled tractor, no-till planter

Table A 4.3: Major Assumptions by Project Intervention for Analysis for each County

Project intervention	Assumptions	
	Huaiyuan County	**Yexian County**
Demonstration and application of fertilizer reduction technology	• all participating farmers are able to apply fertilizer according to the new technology after 5 years • The planting area of both rice and wheat is calculated according to the project implementation area • Project fixed investments are fully depreciated on a 10-year cycle	• all participating farmers are able to apply fertilizer according to the new technology in 5 years • The planting area of both corn and wheat is calculated according to the project implementation area • Project fixed investments are fully depreciated on a 10-year cycle
Demonstration and application of pesticide application reduction and integrated pest management technology	• all participating farmers are able to spray pesticides according to the new technology after 5 years • The implementation area is calculated based on the operating area of a large broadside sprayer • Project fixed investments are fully depreciated on a 5-year cycle	
Demonstration and application of optimized irrigation technology	• all participating farmers are able to follow the new technology for irrigation after 5 years • The planting area of both rice and wheat is calculated according to the project implementation area • Labor cost is calculated at 100 CNY/working day	• all participating farmers are able to follow the new technology for irrigation in 5 years • The planting area of both corn and wheat is calculated according to the project implementation area • Labor cost is calculated at 100 CNY/working day
Demonstration and application of mechanized straw returning to filed and conservation tillage carbon sequestration technology	• all participating farmers are able to return straw to the field according to the new technology in 5 years • The planting area of both rice and wheat is calculated according to the project implementation area • Project fixed investments are fully depreciated on a 10-year cycle	• all participating farmers are able to return straw to the field according to the new technology in 5 years • The planting area of both rice and wheat is calculated according to the project implementation area • Project fixed investments on a 10-year cycle
Demonstration and application of UAV seeding technology	• The implementation area is calculated based on the operating area of a drone • Project fixed investments are updated on a 5-year cycle • Labor cost is calculated at 100 CNY/working day	

Table A 4.4. Results of economic analysis for Huaiyuan County

Project intervention	Main activities	CO_2 at US$40/ton		CO_2 at US$48/ton	
		EIRR (%)	ENPV (million CNY)	EIRR (%)	ENPV (million CNY)
Demonstration and application of emission reduction technologies	(1) Demonstration and application of fertilizer reduction technology	Negative	-107.50	36.59	67.73
	(2) Demonstration and application of pesticide application reduction and integrated pest management technology	67.97	0.68	68.02	46.81
	(3) Demonstration and application of optimized irrigation technology	15.07	260.33	15.80	326.92
Demonstration and application of carbon sequestration technology	(4) Demonstration and application of mechanized straw returning to field and conservation tillage carbon sequestration technology	5.76	-504.88	12.40	37.24
Demonstration and application of UAV	(5) Demonstration and application of UAV seeding technology	36.16	45.92	36.16	45.92
Overall project		**44.28**	**14,402.84**	**45.32**	**15,186.86**

Table A4.5. Results of economic analysis for Yexian County

Project intervention	Main activities	CO_2 at US$40/ton		CO_2 at US$48/ton	
		EIRR (%)	ENPV (million CNY)	EIRR (%)	ENPV (million CNY)
Demonstration and application of emission reduction technologies	(1) Demonstration and application of fertilizer reduction technology	Negative	-68.41	25.13	24.46
	(2) Demonstration and application of optimized irrigation technology	56	2,171	57	2,275
Demonstration and application of carbon sequestration technology	(4) Demonstration and application of mechanized straw returning to field and conservation tillage carbon sequestration technology	12.84	41.69	30.30	937.11
Overall project		**30.76**	**4,550.02**	**34.70**	**5,642.06**

Table A4.6. Results of financial analysis for each project activity - Huaiyuan County

Huaiyuan Project intervention	Main activities	FIRR with subsidy (%)	FIRR without subsidy (%)
Demonstration and application of emission reduction technology	(1) Demonstration and application of fertilizer reduction technology	15.69	Negative
	(2) Demonstration and application of pesticide reduction and integrated pest management technology	125.72	67.92
	(3) Demonstration and application of water saving irrigation technology	15.22	14.32
Demonstration and application of carbon sequestration technology	(4) Demonstration and application of mechanized straw returning to field and conservation tillage carbon sequestration technology	4.99	Negative

Table A 4.7: Results of financial analysis for each project activity - Yexian County

Yexian Project intervention	Main activities	FIRR (with subsidy)	FIRR (without subsidy)
Demonstration and application of emission reduction technology	(1) Demonstration and application of fertilizer reduction technology	Negative	Negative
	(2) Demonstration and application of optimized irrigation technology	95.32	53.69
Demonstration and application of carbon sequestration technology	(3) Demonstration and application of mechanized straw returning to field and conservation tillage carbon sequestration technology	4.89	Negative

Table A 4.8: Comparison of EIRR and FIRR for each project activity under "without subsidy scenario"

Main activities	FIRR without subsidy (%)	EIRR (carbon shadow price "high"at US$80/ton) (%)
Huaiyuan		
(1) Demonstration and application of fertilizer reduction technology	Negative	36.59
(2) Demonstration and application of pesticide reduction and integrated pest control technology	67.92	68.02

Main activities	FIRR without subsidy (%)	EIRR (carbon shadow price "high"at US$80/ton) (%)
(3) Demonstration and application of optimized irrigation technology	14.32	15.80
(4) Demonstration and application of mechanized straw returning to field and conservation tillage carbon sequestration technology	Negative	12.40
Yexian County		
(1) Demonstration and application of fertilizer reduction technology	Negative	25.13
(2) Demonstration and application of optimized irrigation technology	53.69	57.00
(3) Demonstration and application of mechanized straw returning to field and conservation tillage carbon sequestration technology	Negative	30.30

EIRR = economic internal rate of return, FIRR = financial internal rate of return.

ANNEX 5. BORROWER COMMENTS

世行编制的完工报告收悉。完工报告对项目实施情况做了全面、精准的阐述和总结，并给予了高度评价，我办对此完全同意.

我们特别赞同 ICR 的如下评价：

a) 所有关键绩效指标均已实现或超过表明和验证了项目发展目标已完全实现；
b) 项目效率已通过经济财务分析得到证明；
c) 项目与政府部门政策和投资优先事项高度相关；
d) 所有评级客观反映了项目所取得的成就。

我们同意世界银行 ICR 中的经验教训总结. 这些经验教训已被纳入中国绿色农业发展的政府政策制定和投资计划。

此外，我们对报告中某些技术细节在原文中进行了标注和评论 供参考。

我们由衷感谢世行ICR团队付出的辛苦和努力，并赞赏世行 ICR 团队与实施机构和项目利益相关方的互动以及与政府 ICR 团队的密切合作。

我们期待未来与世界银行开展更多合作。

Below translation is provided by WB Beijing Office Translation Group:

The ICRR prepared by the World Bank has been well received. The report has comprehensively and accurately expounded on and summarized the implementation of the project, and highly recognized the project implementation. Our office fully agrees with the contents.

We especially agree with ICRR team's comments as follows:

a) All KPIs have been achieved or exceeded, indicating and proving that the project development goals have been fully achieved.
b) The project efficiency has been proved through economic and financial analysis.
c) The project is highly relevant to government policies and investment priorities.
d) All ratings objectively reflected the achievements of the project.

We agree with the lessons learned from the ICR. These lessons have been incorporated into Chinese government’s policy formulation and investment plans for the development of green agriculture.

In addition, we made comments on some technical details in the original text of the report for reference.

We would like to extend our sincere gratitude to the Bank’s ICRR team for their hard work and appreciate their interactions with the implementing agencies and project stakeholders, as well as their close cooperation with the government’s ICRR team.

We look forward to more cooperation with the World Bank in the future.

ANNEX 6. SUPPORTING DOCUMENTS

- Project Appraisal Document
- Implementation Status and Results Reports (ISRs)
- Aide Memoires
- Restructuring Paper
- World Bank Group (2012) Country Partnership Strategy (CPS) for China, 2013 - 16
- World Bank Group (2019). China Country Partnership Framework (CPF), 2020 - 25
- Government Implementation Completion Report

ANNEX 7. VOICES AND FACES OF FARMERS IN THE PROJECT IMPLEMENTATION

Two farmers from project areas shared their own experience at the Climate Smart Agriculture International Forum held on 23 September 2020. Excerpts below from their speeches:

Pan Yifei, a farmer from Huaiyuan County in Anhui Province.

My village was in the project demonstration area. I want to share the following points.

With the help of the project, we achieved mechanized leveling of the land in my village and the water-saving effect is remarkable. We used to believe that if you want a higher yield, you need more fertilizers. Based on the demonstration of the farmers field school, we were able to conduct soil testing and precise fertilization. We have reduced the amounts of chemical fertilizers by 30 percent. We are also returning straw to the field. Before the project, 90 percent or more of straw and other crop residues burned, causing water soil and air pollution in Huaiyuan County. After the project began, the surrounding farmers also saw the benefits of returning straw to the field, increasing the fertility, and improving soil structure. Now most farmers in the county have adopted this good practice, protecting the green water and blue sky of our living environment.

We achieved carbon sequestration and emission reduction measures while increasing revenue. Our rice output has increased from 450 kg / mu to 550 kg / mu, and the total income per mu can increase by about 300 yuan, the wheat output has also increased from 325 kg / mu to 450 kg / mu, and the income per mu has increased by about 150 yuan. The second income was increased through comprehensive cultivation. Before the project, our cropping pattern was rice and wheat. With the project, we piloted rice-duck, rice-shrimp farming systems with an additional income of about 1,000 yuan per mu. We also introduced melons and vegetable production.

Duck farming in the paddy fields was selected as one of the poverty alleviation products and both the duck and the rice were certified as a pollution-free agricultural product, which are now available on the e-commerce platform, Taobao.com.

Through this project, surrounding farmers have also seen the benefits brought by new technologies and models of climate-smart agriculture, which strengthened their confidence in climate-smart agriculture. More than 80 family farms and cooperatives in the county established the Huaiyuan Scientific Planting and Breeding Development Association and elected me as the secretary general of the association. We all work together to promote the transformation and upgrading of agriculture and make contributions to rural revitalization.

Jia Mantang, a farmer in Yexian County, Henan Province

There are two project activities in my agricultural cooperative: the integration of water and fertilizer (fertigation), and no-tillage.

For carbon sequestration, energy efficiency and emissions reduction measures, we used less pesticides and fertilizers, and increased manure use. The mechanical pesticides spraying greatly reduced the use of pesticides, thus reducing the risks of pesticide residues in food crops, and contamination of soils. Minimizing the use of chemical fertilizers reduced GHG emissions from the farmland. Our water and fertilizer integration adopts the method of " small water and light irrigation ", which guarantees the water needs and demand of crops, and also ensures the purpose of saving water. Our no-tillage technique keeps crop stubble and saves soil moisture while achieving the desired grain yields.

Before the project, we had the old ideas and believed that no yields would be achieved without tillage and with using less pesticides and fertilizers. This idea lasted for a while. Later, the county agriculture bureau staff and the project office organized many field meetings to tell us about the benefits of project implementation and explained the specific measures that required less investment for higher yields, which made us change. Seeing is believing- after the bumper harvest with the increased grain outputs, almost all the farmers in my village have adopted the demonstrated technologies.

In the past five years, the implementation of this project has brought us great benefits and achieved high yields of crops. Our lives have moved towards a well-off life, and we have truly achieved food security. We farmers do not have any great skills, but I think that as long as we plant the land well and produce more high-quality food, we are contributing to the country.

Farmers in Action

Farmers field school (fertigation) in Yexian County

Farmers field school (IPM) in Huanyuan County

Crop residues returning to field demo in Huaiyuan County

Field school on soil fertility test in Yexian County

ANNEX 8. SEQUESTRATION AND EMISSION REDUCTION MONITORING

1. During the first two years of project implementation, the project monitored GHG emissions (N_2O, CO_2, and CH_4) using static chamber-gas chromatography directly in the field. The soil carbon content was determined through a combustion method.[11] To tackle spatial variability and obtain accurate results, the team undertook stratified sampling which accounted for: type of cropping system (rice, wheat, corn, farm forestry); soil type and soil properties (soil texture, pH, organic matter, etc.) type of farm (large-scale household/commercial, family/subsistence; and management (fertilizer, water, and straw, etc.). Table A8.1 presents the data collected directly in the field.

Table A8.1 Field data collection methodology

Parameter	Unit	Description	Monitoring/ Recording Frequency	Measurement Method and Procedure
GHG EMISSIONS				
N_2O	t N_2O/a	Baseline or project N_2O emissions caused by N fertilizer application	Observations were conducted at least twice per month. Sampling frequency was increased after fertilization and irrigation measures. Field data collection was conducted for 2 continuous years.	Field direct monitoring using static chamber- gas chromatography (GC) and using DNDC model simulation.
CH_4	t CH_4/a	Baseline or project CH_4 emissions	Samples were collected at least twice per month Sampling frequency was increased after fertilization and irrigation measures. Field data collection was conducted for 2 continuous years.	Field direct monitoring using Static chamber- gas chromatography (GC) and using DNDC model simulation.
$CSP_{diesel,t}$	L/a	Diesel consumption in year *t*	Amount of fuel consumption for each planting, cultivation, irrigation, harvesting.	Based on the type of machinery, amount and type of fuel consumption, the project calculated the total amount of fuel consumption caused by the mechanical equipment, irrigation, pumping, etc.
$B_{burn,t,i}$	t	Baseline or project straw burning biomass	The amount of straw burning during monitoring period.	Random sampling method.
CARBON SEQUESTRATION				
SOCC	gC/100g soil	Soil organic carbon content	Monitoring once a year during the fourth quarter.	Expert or experienced technician collected soil samples of each soil layer (e.g., 0~10cm, 10 ~ 20cm and 20 ~ 30cm), with 3 replications. A qualified

[11] Soil samples were collected at the 30 cm depth instead of 40 cm in order to adjust the sampling to the local context and limitation of the soil. Per each strata the project collected 3-5 samples.

				laboratory analyzed the samples for soil organic carbon content using carbon and nitrogen analyzer.
BD	g/cm^3	Soil bulk density	Monitoring once a year. Monitoring time is in the fourth quarter of year	At each sampling profile, the undisturbed soil in each layer was sampled through a soil ring to weigh the soil water content and analyze the soil structure. One mixed soil sample per profile was analyzed by a laboratory to measure soil moisture, calculate the dry weight, and the average bulk density.
DBH, H	*cm, m*	DBH, tree height	Monitoring once every 5 years. Monitoring time is in the fourth quarter of year	The plot was selected based on random sampling method (plot size 900m^2), the number of plots varied based on scattered trees variability. Each stratum had at least three plots. Next, average tree diameter (DBH) and height (H), and number of trees was measured. During the last step, aboveground biomass calculated was using ($f_{AB,j}DBH$) and belowground biomass using ratio of aboveground and belowground biomass. Afterward, the cumulative biomass for whole sampling sites was calculated.

Figure A 8.1. GHGs sampling through chamber method.

Figure 8.2. Sampling and monitoring for soil carbon

Figure A 8.3. Sampling sites to calculate aboveground biomass

2. The project used the internationally and nationally approved methodologies[12] to estimate GHG emissions and removals: Clean Development Mechanism (CDM) approved methodology: AMS-III.AU: Methane Emission Reduction by Adjusted Water Management Practice in Rice Cultivation - Version 3.0 (for quantifying methane emissions from rice); Verified Carbon Standard approved methodologies: VM0021: Soil Carbon Quantification Methodology, Version 1.0 (for quantifying soil carbon sequestration); and VM0022: Quantifying N_2O Emissions Reductions in Agricultural Crops Nitrogen Fertilizer Rate Reduction – Version 1.0 (for quantifying emissions from fertilizer use); VM0026: Methodology for Sustainable Grassland Management, Version 1.0 (for quantifying emissions from biomass burning); and China NDRC approved methodology: Forest Management Carbon Sink Project Methodology, Version 01 (for quantifying GHG removes by sinks from agroforestry).

[12] For example, the VCS Program is the world's most widely used voluntary GHG program. Once projects have been certified against the VCS Program's rules and requirements, project developers can be issued tradable GHG credits (Verified Carbon Units (VCUs)). Any methodology developed under the United Nations Clean Development Mechanism (CDM) can be used for projects and programs registering with VCS.

3. After the second year, the project used DeNitrification-DeComposition (DNDC) model[13] to calculate emissions to reduce the cost of measurements and large labor requirements. Soil organic carbon was monitored using direct field sampling, and a subsequent combustion method was used during all five years. The overall cost of soil and GHG sampling analyses was USD$ 231,864.30 which included expenses associated with the laboratory analysis cost (laboratory equipment, experimental materials, pretreatment of soil samples, etc.) and sampling cost (such as travel, labor, car rental, sample transportation, etc.). To run the DNDC model, the project collected the input parameters presented in Table A8.2. DNDC model was verified and calibrated by the observation data of the first two years. The project did not collect a subset of GHGs samples for validating and calibrating the model after the second year.

Table A8.2. Input parameters required by DNDC model

Items	Input parameters
Location	The name of the simulated site, latitude and longitude, and time scale of the simulation
Climate	Daily maximum temperature, minimum temperature and daily precipitation
Soils	Soil pH, texture, bulk density, initial organic matter content of topsoil
Crop	Crop type, multiple cropping or crop rotation type
Management	Sowing and harvesting date, proportion of the aboveground portion of the crop to be returned to the field, ploughing times, time and depth, fertilizer and organic fertilizer application times, time, depth, type and quantity, irrigation times, time and amount of irrigation

Table A8.3. Comparison of the GHG emissions accounting methods

Evaluation method	Introduction	The main advantage	Main shortcomings	Representative methodology
Direct observation	Direct field monitoring of greenhouse gas emissions through static chamber-gas chromatography	• Relatively easy data collection • High accuracy	• High cost • Labor intensive	Clean Development Mechanism (CDM) methodology, Verified Carbon standard (VCS) methodologies
IPCC Emission Coefficient Method	Direct calculation using IPCC Tier 1 emission factors	• Easy data collection • Simple calculation method	• Low accuracy and large uncertainty. • Limited possibility to estimate the outcome of multiple combined interventions • Does not include the calculation of output.	National Greenhouse Gas Voluntary Emission Reduction Methodology of China, Certified Emission Reduction (CCER)

[13] The DNDC model is a biogeochemical model to estimate GHG emissions which is widely used in the world.

Model simulation	It is constructed based on the functional relationship derived from experiments and the laws of biophysical chemistry	• **Low cost** • **Produces multiple scenarios**	• Long-term test data based on field measurements is required; • Requires strong technical knowledge • Required multiple parameters	Verified Carbon standard VCS, American Carbon Registry (ACR)
Method of this project	Integrated direct observation method, emission coefficient method and modelling method.	• Low cost and scalable • **High precision**	• Requires 1-2 years Field monitoring data; • High technical knowledge; • Requires multiple parameters collection directly from the fields	This methodology

ANNEX 9. PROJECT MAP

Figure A9.1. Project Map