

CHINA

Methane-Reducing and Water-Saving Paddy Rice Program for Results (Hunan) (P178796)

TECHNICAL ASSESSMENT

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ABBREVIATIONS AND ACRONYMS

AWD	Alternate Wetting and Drying
CBA	Cost Benefits Analysis
CCER	China Certified Emission Reduction
CH ₄	Methane
CO ₂	Carbon Dioxide
DB	Debt Balance
DLI	Disbursement Linked Indicator
DRA	Debt Repayment Amount
EFA	Expenditure Framework Assessment
ERR	Economic Rate of Return
ESSA	Environment and Social Safeguards Assessment
E&S	Environment and Social
FYP	<i>Five-Year Plan</i>
GHG	Greenhouse Gas
GPBR	General Public Budget Revenue
GPG	Global Public Goods
GWP	Global Warming Potential
HSFCP	High-Standard Farmland Construction Plan
ICR	Implementation Completion and Results Report
IPCC	Intergovernmental Panel on Climate Change
MARA	Ministry of Agriculture and Rural Affairs
MCA	Ministry of Civil Affairs
MOF	Ministry of Finance
MRV	Monitoring, Reporting and Verification
MWR	Ministry of Water Resources
MRWSPRP	Methane Reducing and Water Saving Paddy Rice Program
N ₂ O	Nitrous oxide
NDRC	National Development and Reform Commission
NHSFCP	National High-Standard Farmland Construction Plan
O&M	Operations and Maintenance
PAP	Program Action Plan
PDARA	Provincial Department of Agriculture and Rural Affairs
PDEE	Provincial Department of Ecology and Environment
PDF	Provincial Department of Finance
PDO	Program Development Objectives
PDWR	Provincial Department of Water Resources
PDRC	Provincial Department of Development and Reform Commission
PMO	Program Management Office
PforR	Program-for-Results
PPCG	Provincial Program Coordination Group
RA	Results Area
SIDDs	Self-managed Irrigation and Drainage Districts
TA	Technical Assessment
TFCG	Transfer From Central Government
TOR	Terms of Reference
WUA	Water User Associations

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TECHNICAL ASSESSMENT

1 INTRODUCTION

1. This Technical Assessment (TA) has been carried out as part of the preparation of the Methane Reducing and Water Saving Paddy Rice Program for Results (MRWSPR or the Program). MRWSPR uses the Program-for-Results (PforR) financing instrument and results-based financing approach. The purpose of this TA is to present the World Bank's evaluation of the proposed Program, focusing on the following aspects: (a) strategic relevance and technical soundness; (b) expenditure framework; (c) results framework and monitoring and evaluation capacity; and (d) economic evaluation. The TA has been conducted using the data and support from the Hunan province and other data and information sources, as relevant.

2. The PforR is, overall, anchored in the *High-Standard Farmland Construction Plan for Hunan Province (Hunan HSFCP) 2021 – 2030*, which is a Provincial-level program contributing to the overall objectives of the Government's of China program *National High-Standard Farmland Construction Plan (NHSFCP) for 2021 – 2030*. The plan encompasses cross-cutting and sector-based policies, regulatory and institutional actions, priority support areas, as well as priority investments. The PforR will support a sub-set of activities based on the priorities and targets articulated in the provincial Hunan HSFCP.

2 PROGRAM DESCRIPTION

2.1 Rice Production in China

3. **China is the largest rice producer in the world.** China cultivates a total of 30 million ha for rice production (or 28 percent of the world total; FAO, 2020) and produces over 200 million tons of rice, annually. Rice production is about 40 percent of the total grain production in the country and the main staple food for around 60 percent of China's 1.4 billion population. Majority of the rice is produced in the fully irrigated areas. China is the sixth largest rice exporter in the world, accounting for almost 4 percent of the global rice exports.¹

4. **Rice production practices prioritize achievement of high yields and production efficiency.** Driven by the need for food self-sufficiency, the policies in the rice sub-sector, similar to the rest of the agriculture sector, have been promoting high-yield and high efficiency cultivation technologies over the past decades. These technologies were rigorously applied by farmers, leading to high rice yields almost every year.

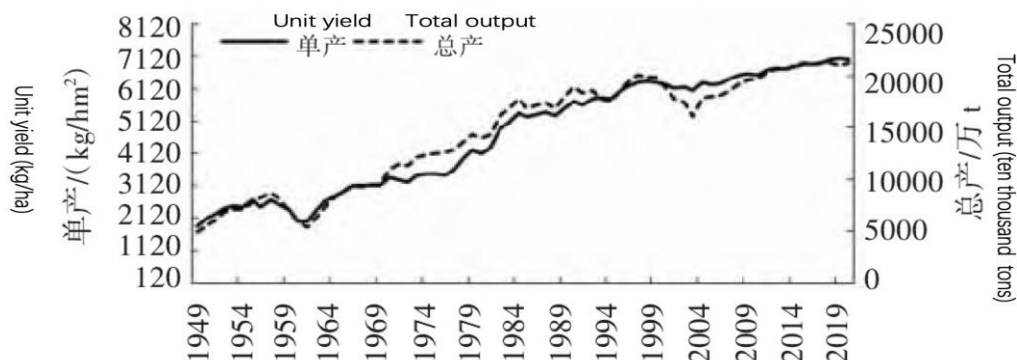
5. **The unit yield of rice in China has increased steadily through a series of high-yield and stable yield cultivation technology innovations over past decades as shown in Figure 1.**² Although the per unit yield of rice in China is higher than the global average, there is still a certain gap comparing with Australia, the United States and other countries. According to the data released by FAO, in 2020, the per unit yield

¹ International Trade Center (ICT), 2021.

² 中国水稻生产、市场与进出口贸易的回顾与展望[] 徐春春,纪龙,陈中督,方福平.中国稻米. 2021 (04)

of rice in China was 7,040 kg/ha and the global per unit yield of rice was 4,609 kg/ha, while the per unit yield of rice in Australia and the United States reached 10,031 kg/ha and 8,540 kg/ha respectively.³

Figure 1: Changes of rice yield per unit area and total yield in China from 1949 to 2020



Source: Review and Prospect of China's rice production, market and import and export trade (Xu Chunchun, et al).

6. **Rice cultivation practices.** Direct seeding and seedling transplanting are the two basic rice cultivation technology systems applied in China. Over years, a variety of cultivation modes have been gradually evolved. For example, the direct seeding has changed from sowing direct seeding to dry direct seeding and mechanical direct seeding, and manual transplanting has changed to light, simplified and efficient manual seedling throwing and mechanical transplanting. In recent years, due to the adjustment of economic structure, the shortage of rural labor force, the increase of rice production cost and the reduction of rice planting efficiency, rice cultivation techniques have undergone significant changes in the following aspects: first, farmers spontaneously transformed rice transplanting into direct seeding. With the improvement of mechanical direct seeding technology, the traditional direct seeding has changed to simplified cultivation such as mechanical drill seeding and precision hole direct seeding; and second, the use of chemical fertilizer, pesticide and irrigation water maintain a high level and the utilization efficiency is relatively low, and the farmland ecosystem has been polluted. In the future, the direction of rice cultivation technology is progressing toward mechanization, improved rice varieties, factory oriented seedling, green production through rational use of fertilizers and pesticides, integration of crop and animal production.⁴

7. **Fertilizer use in rice production.** Rice cultivation is dominated by chemical fertilizers. By 2018, fertilizer was overused in all zones of rice production.⁵ It is estimated that China consumes more than 20 million tons of nitrogen fertilizer every year, of which about 25 percent is used for rice cultivation (Figure 2). This translates to about 37 percent of the global rice nitrogen fertilizer application.⁶ In the past 30 years, the average nitrogen fertilizer application rates of rice in Northeast, southwest, middle reaches of the Yangtze River (early rice), South China (double cropping) and Yangtze River Delta are N 159, 173, 179, 284 and 279 kg/hm² respectively, and the average nitrogen fertilizer application rate of rice in China is N

³ Special report on rice industry: the loose trend of rice supply and demand in China is expected to continue, <http://finance.sina.com.cn/stock/stockzmt/2022-04-04/doc-imcwipii2302615.shtml>

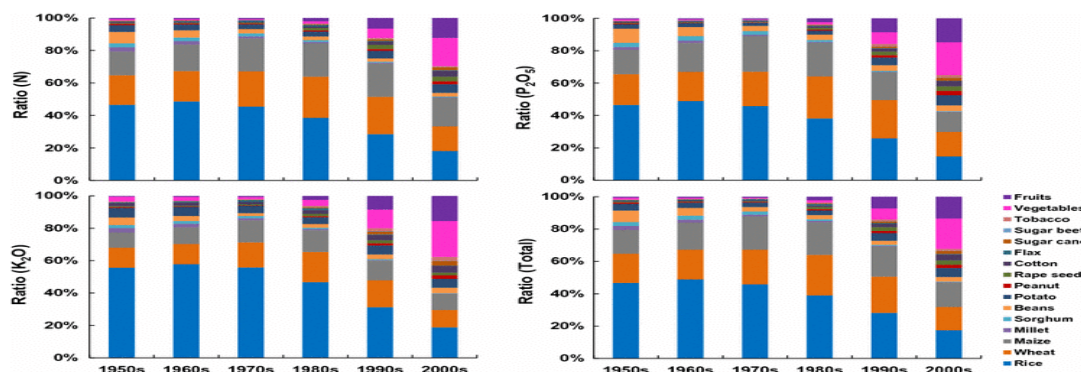
⁴ 梁玉刚,李静怡,周晶,吴涛,方宝华,余政军.中国水稻栽培技术的演变与展望[J].作物研究, 2022, 36(02):180-188.

⁵ 近 30 年中国稻区氮素平衡及氮肥偏生产力的时空变化[J]. 黄晶,刘立生,马常宝,薛彦东,韩天富,柳开楼,刘淑军,张璐,李冬初,都江雪,张会民. 植物营养与肥料学报. 2020(06)

⁶ Various sources.

215 kg / hm². Except for the southwest rice region, the nitrogen application rate in other rice regions is high.⁷ Despite the high application rates, fertilizer use efficiency is less than 40 percent, contributing significantly to GHG emissions and water pollution, while unnecessarily increasing production costs.

Figure 2: Shares of N, P, K fertilizer consumption for various crops 1950s-2000s



Source: Chen, X., et al. *Nutrient Cycling in Agroecosystems*, 2018

8. **Paddy soil is the largest and most widely distributed type of arable land in China.** By using data from the 136 national sites for long-term monitoring on paddy soil, a study⁸ found out that under the conventional farmer's fertilization in the past 30 years, the soil fertility has slightly improved, and the productivity level is significantly increased in paddy soils of China, despite of the trend of acidification. The increment of soil fertility and productivity is mainly owing to the significant increase of soil available P and readily available K contents, while the total nitrogen and organic matter contents are the obstacles. So, more attention should be paid to the input of organic materials and the balanced application of N, P and K fertilizers for stable and sustainable fertility and productivity of paddy soils in the future.

9. **Current irrigation practices in the rice production system.** Rice is a water intensive crop, it is mainly grown on irrigated land. Rice production uses over 30 percent of the total water consumption in China, contributing to increasing water stress and water pollution in various river and lake basins. In the major rice producing areas the water application to paddy fields can be as high as 13,500 m³/ha. Although continuous and heavy public investments in irrigation infrastructure modernization have been made over the past decades, irrigation services are highly subsidized in majority of the irrigation districts, with low operations and maintenance (O&M) cost recovery from low irrigation service charges, which are mostly paid based on land area rather than volume of water used. This in turns limits available funding for O&M, resulting in inadequate and deferred maintenance. The deferred maintenance leads to the deterioration of the irrigation infrastructure and services, which disincentivizes the farmer water users to pay for the services. Further, the slow replication of successful AWD pilots in various forms among different rice producing provinces of China is also closely related to the underperforming irrigation services. With the national government determined to deepen the irrigation management reform including mainstreaming the agricultural water pricing reform during the 14th FYP period and the fact that the rice production is

⁷ 近 30 年中国稻区氮素平衡及氮肥偏生产力的时空变化[J]. 黄晶,刘立生,马常宝,薛彦东,韩天富,柳开楼,刘淑军,张璐,李冬初,都江雪,张会民. 植物营养与肥料学报. 2020(06).

⁸ WU Hong-liang, WANG Shi-chao, YAN Zhi-hao, HUAI Sheng-chang, MA Chang-bao, XUE Yan-dong, XU Ming-gang, LU Chang-ai. Evolution characteristics of fertility of typical paddy soil in China in recent 30 years. *Journal of Plant Nutrition and Fertilizers*, 2018, 24(6): 1416-1424.

increasingly by larger scales (large farmers, farming cooperatives and enterprising) who are more sensitive to innovative technologies and good management practices and can afford higher water tariff, there are opportunities to substantially improve irrigation services and scale up the win-win irrigation/water management practices, especially if coupled with revenue-generating interventions such as water right trading and carbon financing.

10. **The rice production in China is a major source of greenhouse gas emissions, with even higher rice methane emission sharing and water use.** The high-yield and high efficiency cultivation technologies prioritized for rice production have contributed to agriculture's significant environmental and carbon footprint. China accounts for 19 percent of the global methane and 11 percent of global agricultural nitrous oxide emissions respectively, whose global warming potential (GWP) are 34 and 296 times that of carbon dioxide (CO₂), respectively (UNFAO, 2022). Rice production has even higher methane emission sharing in China— China is the world's largest methane emitter,⁹ while rice accounts for 40 percent of China's agricultural methane emissions and 16 percent of the country's total methane emissions.¹⁰ Rice production in China also relies heavily on irrigation. Over 90 percent of rice areas in China are irrigated, much higher than the global average. Fertilizer and pesticide use in rice production in China is excessive and inefficient, contributing to significant environmental and carbon footprints.¹¹ Rice cultivation and nitrogen fertilizer application are the main sources of methane and nitrous oxide in the agricultural sector, accounting for 40 percent and 47 percent, respectively (Cheng and Pan, 2021). It is estimated that about 8.0 Tg of CH₄ and 154 Gg of N₂O are emitted annually from rice fields (Sun et al., 2018), which contribute to over 20 percent of the total GHG emissions (in CO₂ equivalent terms) from the country's agricultural sector.

11. Studies have shown that GHG emissions and carbon footprint are varied among rice regions in China and fluctuated over the past decades: (1) the greenhouse gas emissions and carbon footprint per unit area of rice production in China increased year by year, while the carbon footprint per unit yield showed a downward trend, with an average annual growth of 2.124 billion kgCO₂ EQ, 32.58 kgCO₂ EQ/hm² and -2.82 kgCO₂ EQ/T respectively; (2) due to the variations of rice production conditions in different provinces, there are great differences in their carbon footprint (Table 1); (3) in terms of average annual carbon footprint per unit output, the highest in Hainan is 1419.35 kgCO₂ EQ/T, and the lowest in Jilin is 602.12 kgCO₂ EQ/T; (4) comparing the carbon footprint of unit area and unit yield, it is found that the carbon footprint of double cropping rice areas in South China (Guangxi, Guangdong, Fujian, etc.) and central China (Jiangsu, Hunan, Jiangxi, etc.) are higher than the national average.¹²

Table 1: Rice production and carbon emission in the middle and lower reaches of the Yangtze River

Province or city	Area, km ²	Yield, Million MT	Total carbon emission Mt CO ₂ -eq	Total carbon emission Mt C-eq	Total carbon sequestration Mt C-eq
Hunan	4,009	26.74	29.48	8.04	9.24

⁹ Kirschke et al. (2013) Three decades of global methane sources and sinks, Nature Geoscience., 6, 813–823. ([link](#))

¹⁰ The People's Republic of China, Second Biennial Update Report on Climate Change. ([link](#))

¹¹ To ensure the country's food security, China developed intensive crop production systems, consistently applied new, more productive infrastructure, production technologies and rice varieties. At the same time, China relied on excessive and inefficient use of fertilizers, pesticides, and irrigation water inputs. These technologies were rigorously applied by farmers, leading to high rice yields almost every year. As a result, China's average yield is around 6.5 tons per hectare, which is among the highest in Asia (International Rice Research Institute, IRRI). According to the IRRI, 49 super rice varieties have been released in China since 1999, with yield increases to as much as 12 tons per hectare. China is also the largest adopter of hybrid rice.

¹² 水稻生产碳中和现状及低碳稻作技术策略[J] 陈松文,刘天奇,曹凑贵,凌霖,王斌.华中农业大学学报. 2021 (03)

Jiangxi	3,436	20.92	29.78	8.12	7.23
Anhui	2,545	16.81	26.86	7.33	5.81
Hubei	2,391	19.66	22.38	6.10	6.79
Jiangsu	2,215	19.58	18.38	5.01	6.76
Zhejiang	651	4.77	5.44	1.48	1.65
Shanghai	104	0.88	0.87	0.24	0.30

Source: Current situation of carbon neutralization in rice production and technical strategy of low methane rice cultivation (Chen Songwen, et al).¹³

12. **Reducing rice GHG emissions in China, especially methane emissions, is important to climate change mitigation globally.** Methane accounts for about half of the net rise in global average temperature since the pre-industrial era.¹⁴ Methane is a much more powerful GHG than carbon dioxide (CO₂), however, it is also short-lived.¹⁵ In the first 20 years after its release, methane is around 80 times more powerful than carbon dioxide in global warming potential (GWP).¹⁶ But it also breaks down much more quickly than carbon dioxide. This means that curbing methane emissions could rapidly reduce the rate of global warming, leading to near-term gains in battling climate change. Therefore, the 26th United Nations Climate Change Conference of the Parties (COP26) Global Methane Pledge highlighted that rapidly reducing methane emissions is regarded as the single most effective strategy for keeping the goal of limiting warming to an additional 1.5°C within reach; this strategy will also yield co-benefits of improving public health and agricultural productivity.¹⁷ In November 2021, China signed the U.S.-China Joint Glasgow Declaration on Enhancing Climate Action in the 2020s,¹⁸ which underscores actions to enhance methane measurement and mitigation, as well as incentives and programs to reduce methane from the agriculture sector. The COP27 reiterated the importance of reducing methane emissions, including reducing methane from rice cultivation. At COP27, China announced it had drafted a methane reduction plan, including reducing methane emissions from the agricultural sector.

13. **Rice production is also vulnerable to climate change.** A large number of studies have shown that the continuous change of climate has a negative impact on rice, such as shortening the growth period, declining per unit yield, uneven quality and rising production costs. For instance, the continuous rise of temperature has a significant impact on the growth period of double cropping rice in the middle reaches of the Yangtze River. If the temperature increases by more than 2.5 °C, the unit yield of rice will continue to decline.^{19,20} The increase of temperature also leads to extra water evaporation in the soil. On the one hand, it accelerates the decomposition rate of existing nutrients such as organic matter and organic carbon in the soil and weakens the soil fertility. It also accelerates the decomposition rate of chemical fertilizer, rapidly releases available nitrogen, reduces the fertilizer utilization efficiency and weakens the soil's fertilizer fixation capacity. These effects eventually lead to the increase of field fertilization and production cost which will ultimately have adverse impact on the environment. In addition, climate warming, especially the warming in winter, has prolonged the period of diseases and pests, expanded the

¹³ Ibid.

¹⁴ Global Methane Pledge ([link](#))

¹⁵ IPCC (2021). Sixth Assessment Report. Chapter 5. ([link](#))

¹⁶ Control methane to slow global warming — fast, Nature 596, 461 (2021) ([link](#))

¹⁷ Global Methane Pledge ([link](#))

¹⁸ U.S.-China Joint Glasgow Declaration on Enhancing Climate Action in the 2020s ([link](#))

¹⁹ A climate-smart perspective for rice sustainability in China [A]. Abdulkareem Raheem, Yu Jiang, Weijian Zhang. 2018

²⁰ 万信, 王润元. 气候变化对陇东冬小麦生态影响特征研究[J]. 干旱地区农业研究, 2007, 25 (4) :80-84.

geographical scope and intensified the degree of damage, resulting in the increased application of pesticides and herbicides, higher labor and production costs.^{21,22,23,24}

14. Decades of research and piloting in China have demonstrated that a package of integrated solutions is the most cost-effective way of reducing rice GHG emissions. In the major rice production regions in south China, methane emissions account for around 65-75 percent of the total rice GHG emissions, while fertilizer application accounts for 5-10 percent of total emissions, straw burning contributes to 5-20 percent of emissions²⁵, and agricultural machinery is responsible for 5-10 percent of emissions.²⁶ Water-saving technologies, such as alternate wetting and drying (AWD), can reduce 50 percent of methane emissions and 30 percent of water use without reducing yields.^{27, 28} In AWD, the rice field gets alternately flooded and non-flooded, which reduces submergence, leading to the significant reduction of methane emissions and water use. Besides the water saving techniques for methane emission reduction, other agricultural solutions are also critical to further reduce rice GHG emission. Better fertilizer and pesticide management can reduce emissions, especially the emissions of nitrous oxide. In particular, as the application of AWD may increase nitrous oxide emission,²⁹ co-management of water and fertilizer application can ensure that the nitrous oxide emissions remain low.³⁰ These benefits extend to the reduction of non-point source pollution from rice cultivation. Straw returning can improve soil fertility and increase soil carbon sequestration. However, the decomposition of fresh crop straws under anaerobic soil conditions can also increase methane emissions. Combining AWD with straw returning can allow seven to ten days of aerobic decomposition of straw residues, which will significantly lower methane emissions.^{31, 32} Thus, the co-management of water and straw is also critical. In addition, off-farm straw utilization (such as biochar, mushroom substrate, fertilizer producing, and feeding), optimal rice varietal selection, direct dry seeding, improved machinery management, reduced post-harvest loss and food wastes³³ can also contribute to the reduction of rice GHG emissions.

²¹ A climate-smart perspective for rice sustainability in China [A]. Abdulkareem Raheem, Yu Jiang, Weijian Zhang. 2018

²² 万信, 王润元. 气候变化对陇东冬小麦生态影响特征研究[J]. 干旱地区农业研究, 2007, 25 (4) :80-84.

²³ 刘颖杰, 林而达. 气候变暖对中国不同地区农业的影响[J]. 气候变化研究进展, 2007, 3 (4) :229-233.

²⁴ 白莉萍, 林而达. CO₂浓度升高与气候变化对农业的影响研究进展[J]. 中国生态农业学报, 2003, 11 (2) :132-134.

²⁵ It should be note that since xxx, China has introduced a ban on straw burning in the fields.

²⁶ Zhang, D., Shen, J., Zhang, F. et al. (2017) Carbon footprint of grain production in China. Scientific Reports 7, 4126. ([link](#)). The results were based on the life cycle analysis of carbon emissions per unit yield (kgce/kg).

²⁷ Richards M, Sander BO. 2014. Alternate wetting and drying in irrigated rice. Climate-Smart Agriculture Practice Brief. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). ([link](#))

²⁸ Jiang Y. et al., 2019. Water management to mitigate the global warming potential of rice systems: A global meta-analysis. Field Crops Research ([link](#)).

²⁹ Unlike methane emissions, nitrous oxide emission is generally low under waterlogged conditions, because nitrification and denitrification (both of which can produce nitrous oxide) of mineral N is limited. The drying of paddy field can significantly reduce methane emissions, but it may also increase nitrous oxide emissions. It was estimated that, under AWD, 15–20 percent of the benefit gained by decreasing methane emission is offset by the increase in nitrous oxide emissions. However, the net GWP is still significantly lower under AWD than in continuously flooded fields, due to the substantial reduction of methane emissions under AWD. Richards M, Sander BO. 2014. Alternate wetting and drying in irrigated rice. Climate-Smart Agriculture Practice Brief. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). ([link](#)); Yu Jiang, Daniela Carrijo, Shan Huang, et al. (2019) Water management to mitigate the global warming potential of rice systems: A global meta-analysis, Field Crops Research, Volume 234, Pages 47-54, ISSN 0378-4290 ([link](#))

³⁰ Balaine, N., Carrijo, D.R., Adviento-Borbe, M.A. and Linquist, B. (2019), Greenhouse Gases from Irrigated Rice Systems under Varying Severity of Alternate-Wetting and Drying Irrigation. Soil Science Society of America Journal., 83: 1533-1541. ([link](#))

³¹ Hang X. et al., 2014. Differences in rice yield and CH₄ and N₂O emissions among mechanical planting methods with straw incorporation in Jianghuai area, China. Soil and Tillage Research 144, 205-210

³² Linquist B. A. et al., 2015. Reducing greenhouse gas emissions, water use, and grain arsenic levels in rice systems. Global Change Biology. 21, 407-417. ([link](#))

³³ Methane emission contributes to the largest portion of rice GHG emissions. Post-harvest systems, including processing, waste

15. **China is an active promoter of reducing agricultural emissions through policy supports and technical innovations.** In 2007, the Ministry of Agriculture listed 10 key agricultural and rural technologies for saving energy and reducing emissions, including the use of straw and manure. 2009 saw the launch of a series of **programs** supporting the development and application of agricultural technologies and approaches designed to combat climate change. In 2017, agricultural low-carbon and emissions-reducing technologies were included on a list of key low-carbon technologies issued by the National Development and Reform Commission. And over the years, national agricultural development plans have directly or indirectly worked to bring about early peak carbon and carbon neutrality.³⁴

16. **In terms of adaptation measures, many of the above-mentioned low carbon technologies would also increase the on-farm resilience to climate change.** Mitigating strategies such as alternate wetting and drying, limiting chemical fertilizers and pesticide application by precise farming, usage of rice cultivars with low methane emission, recycling of farm waste into organic fertilizers, are important strategies to increase rice farm adaptation to climate change. Development of high-yielding and abiotic stresses-tolerant (temperature, drought) and resistance rice cultivars, as well as deploying other production management options such as development of weather-proofed farm equipment, shifting of planting and adjustments in cropping dates and use of climate forecasting by using remote sensing and modeling can also be used to sought out the climatic issues.³⁵ In addition, it is important to ensure that the outreach and information channels for farmers, awareness-raising activities, training and extension services are available to farmers to ensure uptake and mainstreaming of the new technologies.

2.2 Emission Trading Scheme Development in China

17. **Progress of China's Agricultural Carbon Market Development.** Since the launch in July 2021, China's National Carbon Emission Trading System (ETS) has become the world's largest carbon emission trading system, with a cumulative trading volume of more than 800 million yuan. The plan currently covers only one sector: power sector, where the annual carbon dioxide emissions of more than 4 billion tons, accounting for 30-40 percent of the national total or 10-15 percent of global carbon dioxide emissions. The expanded plan will cover eight industries (power generation, petrochemical, chemical, cement, steel, non-ferrous metals, pulp and paper, aviation building materials) in the next few years, including institutional and individual investors. However, the government has not yet released an official roadmap or timetable for expansion of sectors. On September 28, 2022, the Ministry of Ecology and Environment of China announced that the current status of the Interim Regulations on the Administration of Carbon Emission Trading is pending, but believe that the promulgation of the Regulations can be expected. The "revised draft" makes it clear that local carbon emission trading markets will not be built after the implementation of the regulations, and the existing local carbon emission trading markets will gradually be incorporated into the national carbon emission trading markets. The "revised draft" proposes to encourage enterprises and institutions to implement renewable energy, forestry carbon sink, methane utilization and other projects in China, so as to achieve the replacement, adsorption or reduction of greenhouse gas emissions, and generate certified greenhouse gas emission reductions. According to media report, in terms of the scope of emission control, in accordance with the principle of "stressing the large and deregulating the small", China will try to bring

disposal, and transportation, only account for a small portion of rice GHG emissions through the rice value chains in China. Thus, this PforR Program will mainly focus on the reduction of rice GHG emissions during rice production. Huayang Zhen, Xu Feng, Muhammad Ahmed Waqas, et al. (2023), Solutions to neutralize greenhouse gas emissions of the rice value chain — A case study in China, Sustainable Production and Consumption, Volume 35, 2023, Pages 444-452, ISSN 2352-5509 ([link](https://www.sciencedirect.com/journal/Sustainable%20Production%20and%20Consumption))

³⁴ China Dialogue, January 22, 2021. <https://chinadialogue.net/en/food/how-can-china-cut-emissions-from-its-farms/>

³⁵ Rice Production Under Climate Change: Adaptations and Mitigating Strategies, Sumera Anvar, Durham University, June 2020

the large-scale livestock and poultry (pigs, chicken, cattle, etc.) industry with large carbon emissions into the scope of mandatory emission control, and gradually expand it to other agricultural fields such as farmland planting, integrated crop and livestock farming. In terms of trading products, in accordance with the principle of "mature one, develop one", biogas carbon emission reduction, forestry carbon sink, wetland carbon sink, etc. were the main trading products at the initial stage, and gradually expanded to other agricultural carbon trading products such as farmland carbon sink, soil testing based formula fertilization carbon fixation and emission reduction, fertilizer and pesticide carbon reduction.

18. **As a most significant pilot, Xiamen Property Rights Trading Center has completed 42.8 million tons of green ecological environment rights and interests trading, covering water rights trading, green certificate trading, blue carbon trading, agricultural carbon trading, etc.** In particular, since the establishment of the first agricultural carbon sink trading platform in China under the center in May 2022, agricultural carbon sink trading exceeded 100,000 tons in the first three months. Specifically, (1) Cooperating with the Rural Commercial Bank of China to promote the "carbon sequestration loan for rural revitalization" with an amount of CNY 3.5 million, the new mechanism of "promoting rural green transactions with green vouchers, promoting green income of farmers with green transactions, and promoting green agricultural development with green finance" was opened. (2) in terms of supporting the development of marine economy, Xiamen Property Rights Trading Center has developed the first mangrove marine carbon sequestration methodology in China. At the beginning of this year, the Center completed the country's first marine fishery carbon sink transaction of 15000 tons, achieving a "zero breakthrough" in China's marine fishery carbon sink transaction. (3) in terms of helping the development of the digital economy, after the first national "agricultural carbon sink trading to help rural areas, digital RMB available for over 10000 people to buy" activity was held in cooperation with the Agricultural Bank of China, Xiamen Property Rights Trading Center also signed a carbon sink satellite digital measurement cooperation agreement with the National Remote Sensing Application Engineering Technology Research Center, among others, and the first batch of satellite aided measurement areas reached 21000 mu.

19. On March 30, 2023, the Ministry of Ecology and Environment (MEE) officially announced its plan to open the national voluntary carbon market, and called for proposals to develop and refine the methodologies for voluntary GHG emission reduction projects, including the methane reduction projects in agricultural sector.³⁶

2.3 Rice Production in Hunan and Participating Provinces

20. **Rice production practices in Hunan and Program counties.** Hunan Province is the province with the largest rice area in China, as well as a top double-season rice producing province in China (Figure 3). It, therefore, has a high potential to lead the way in water-saving and low-methane rice production. Hunan Province is selected under the support of this proposed Program for Results (PforR) Program. Hunan Province has 4.2 million ha of rice harvested areas,³⁷ which is nearly the same rice harvested area of the Philippines and around 60 percent of that area in Vietnam. Around 85 percent of the farmlands in Hunan are used to produce single- and double-cropping rice, with majority of the of the area under double-cropping (Figure 4(a)). The province uses transplantation method in rice production.

Figure 3: Rice Production Area in Hunan Province

³⁶ MEE. Public Solicitation of Methodologies for Greenhouse Gas Voluntary Emission Reduction Projects. [\(link\)](#)

³⁷ China Statistical Yearbook, 2018. [\(link\)](#).

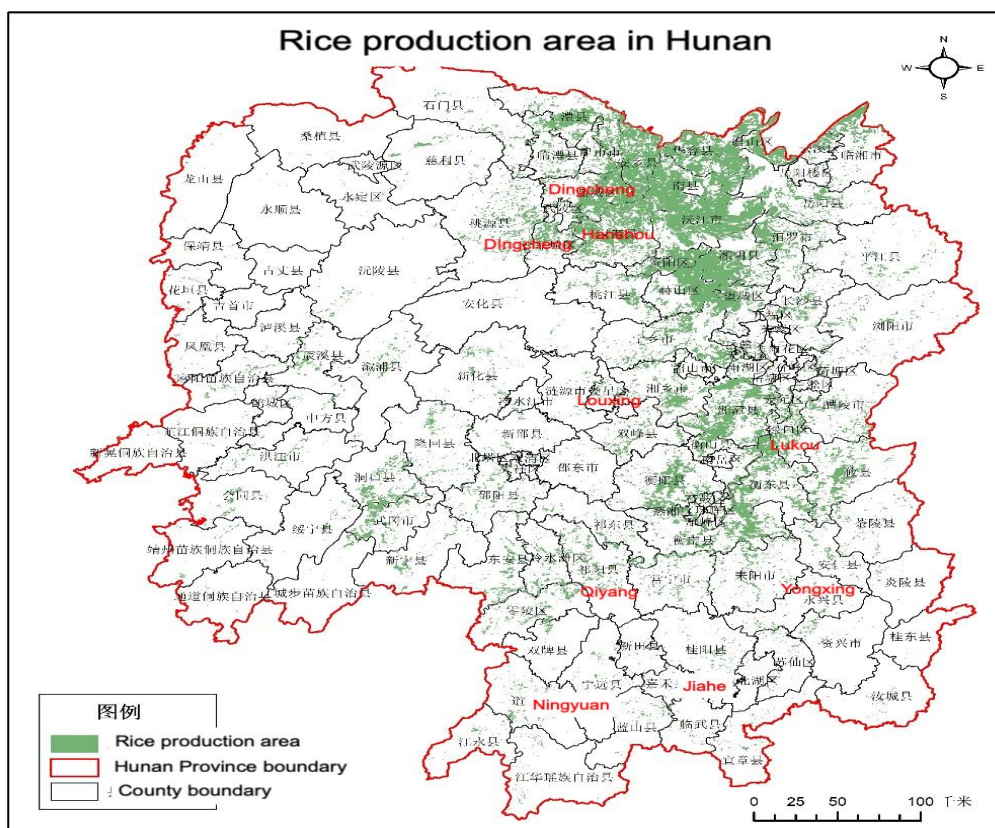
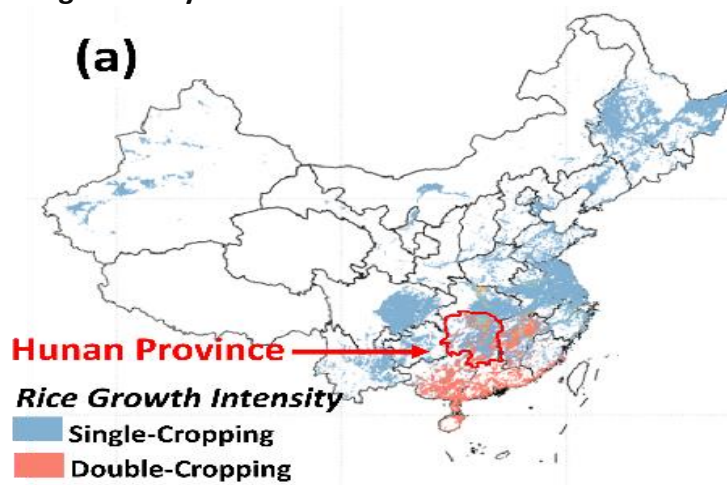


Figure 4(a): Rice growing intensity.



21. The rice areas and rice output in the Program counties (Table 2) is as follows:

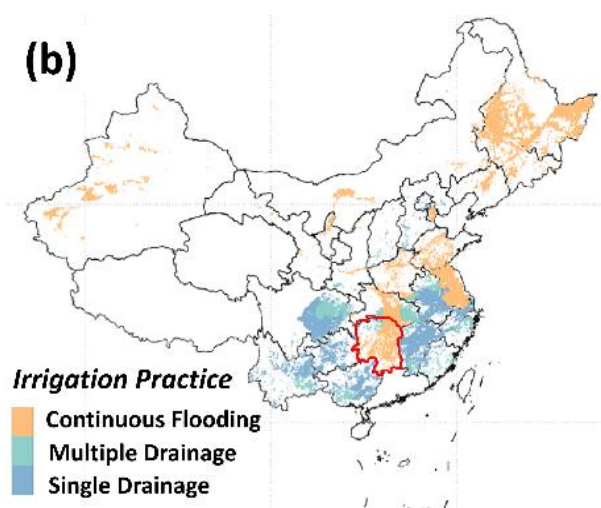
Table 2: Rice Production Area and Output, 2021

County/Districts	Area under Rice (all varieties), ha	Production Output (million MT)	Average Yield (kg/ha)
------------------	-------------------------------------	--------------------------------	-----------------------

Lukou District	27,307	0.1804	6,606
Jiahe County	12,000	0.0732	6,096
Qiyang County	43,000	0.2635	6,128
Louxing District	15,660	0.1089	6,956
Dingcheng District	98,727	0.6279	6,360
Hanshou County	90,827	0.5685	6,259

22. **Irrigation practices in the Province and Program counties.** Hunan produces 13 percent of China's total rice production in water intensive manner. Majority of the rice areas in Hunan are surface water irrigated. Hunan had promoted rice water saving techniques in the 1990s and the current water saving techniques used in Hunan should be updated considering the changes of agronomic practices, soil conditions, and climate. However, the adoption of these technologies is low and many farmers are still practicing continuous flood irrigation (Figure 4(b)), especially on the farmlands where drainage facilities are unavailable or deteriorated.

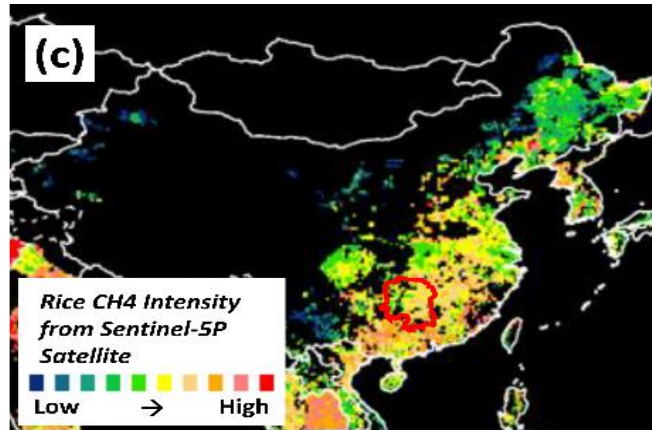
Figure 4(b): Irrigation Practices in Hunan Province.



23. **As result of the above, Hunan is a hotspot of rice methane emissions** as confirmed by data from the Sentinel-5P satellite.³⁸ (Figure 4(c)) Hunan Province has the ambitious government's program to establish high-standard farmlands with improved infrastructure and irrigation services in 85 percent of the cultivated lands by 2030. Embedding and scaling up water saving and low methane rice practices through this ambitious provincial program will have a high potential to reduce rice GHG emissions and save water.

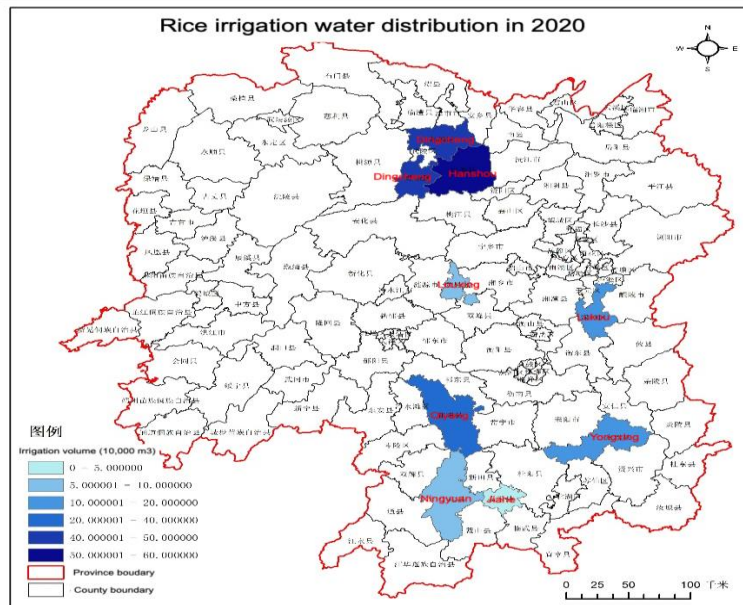
Figure 4(c): Emission intensity in Hunan province.

³⁸ World Bank researchers developed a new database and open data service for tracking methane emissions ([link](#)). It uses information from the European Space Agency's Sentinel-5P satellite platform, which provides reliable information on global methane emissions. The methane emission data from rice fields were analyzed. Dasgupta, Susmita; Lall, Somik V.; Wheeler, David. (2022). Tracking Methane Emissions by Satellite : A New World Bank Database and Case Study for Irrigated Rice Production. Washington, D.C. : World Bank Group. ([link](#))



Irrigation water for rice use in the Program Counties.

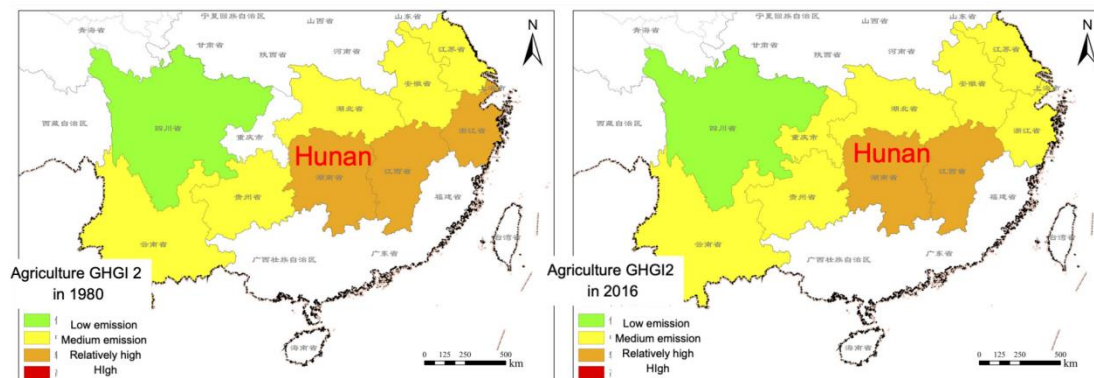
Figure 5: Grading map of rice irrigation water volume in the Program Districts and Counties in 2020



Greenhouse Gas (GHG) Emissions

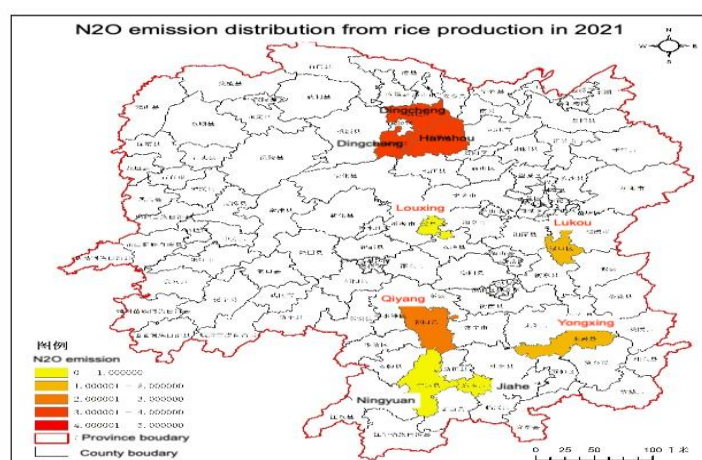
24. **Emission Intensity.** The carbon footprint per unit of output in the double-cropping rice production area in Central China, where Hunan is located, is greater than the national average indicating the high carbon footprint of double-cropping rice. From 2004 to 2014, the average annual increase in greenhouse gas emissions from rice production in Hunan was 291 million kg CO₂-eq. In terms of carbon footprint per unit of rice production, Hunan, like most regions in China, showed negative growth. In terms of carbon footprint per unit area of rice production, the average annual carbon footprint per unit area of rice production in China is 5,805 kg CO₂-eq/hm², which is higher than the national average in Hunan Province.

Figure 6: Increase in emission intensity in Hunan, comparing 1980 and 2016



25. The N_2O emission statistics of the Program counties in Hunan Province – data from 2021 – is shown in Figure 7 below. It can be seen from the Figure that the rice N_2O emissions in Hanshou County and Dingcheng County were higher than in other Program counties.

Figure 7: N_2O Emission Distribution from Rice Production in 2021

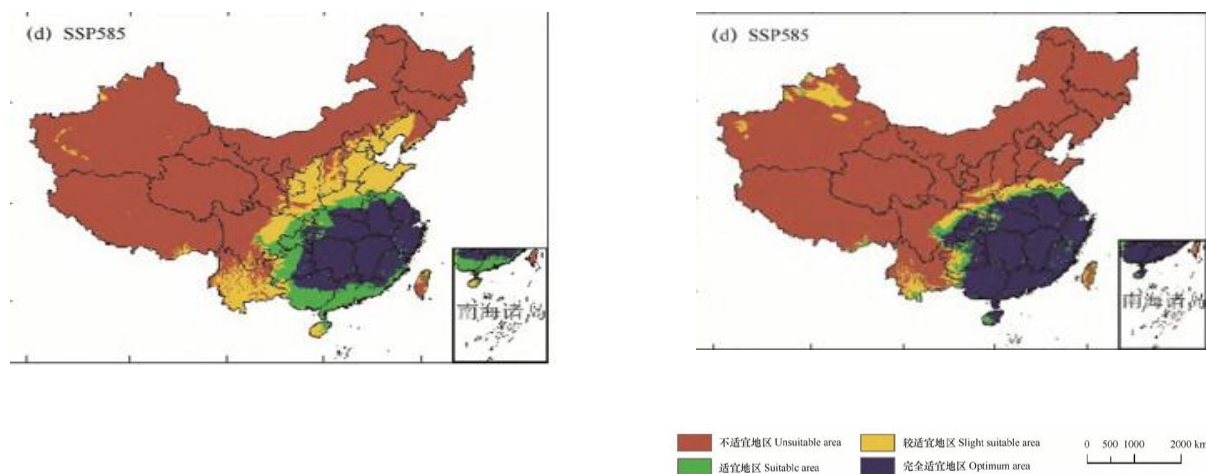


26. CH_4 emissions. Hunan Province is located in the Yangtze River Economic Belt of China. According to the statistics of the greenhouse gas emission intensity of unit farmland in the Yangtze River Economic Belt of China in 2019, the last 4-year (2018 – 2021) average concentration of atmospheric CH_4 at Jinsha Station near Hunan Province is 2032 ± 12 ppb. Compared with the previous 4-year period, it showed an increasing trend.

27. Even with climate change research shows that Hunan Province will remain a key area for rice planting in the future, therefore it is very important to transform the rice production in the province, and use the lessons learned and tested methodologies to transform the rice production in China overall. Researchers (Lv Tong et al) conducted analysis on the field data of rice (both double cropping and single cropping, as well as both early and late varieties) both to learn lessons from the historical data (1970-2000), but also to do a projection for the future period (2081-2100). With the results showing that compared with the historical period, the proportion of suitable planting area for rice in the future would significantly increase, Hunan Province remains a key optimal rice cropping area in the future (Figure 8).³⁹

³⁹ 基于 MaxEnt 模型预测未来气候变化情景下中国区域水稻潜在适生区的变化[J]. 吕彤,郭倩,丁永霞,刘力,彭守璋.中国农

Figure 8: Climate suitable area of rice planting distribution during 2081-2100, Early Rice (left side) and Late Rice (right side)



28. Delivery of Agricultural Services, Information and Extension Services to Farmers. Hunan Province has a solid training and extension service system, which can be leveraged to promote low-methane rice production. Based on the communications with provincial and county governments and stakeholders, it was found that Hunan province and the Program counties have a solid foundation in terms of agricultural technology training and services. The agricultural technology extension and demonstration service organizations at the provincial, municipal, and county levels are relatively sound. However, the technical service capabilities at the township and village levels are relatively weak. Hunan province and the Program counties have relatively rich training experience in rice production technology, relatively strong service capabilities, and relatively comprehensive training content, which can be leveraged to enhance the farmer's capacity for adopting mitigation measures. However, the trainers and local experts are lack of understanding on rice GHG emissions and related mitigation measures. Female farmers are not fully engaged in the training.

29. Hunan Province is highly committed to climate adaptation and mitigation in the agricultural sector. Rice production in Hunan is highly vulnerable to climate change, with high exposure to floods and droughts.^{40, 41} In 2020, Hunan had around 7 million people and over 95 percent of the counties suffered from another major flood after the devastating 1998 flood.⁴² In 2022, Hunan was heavily hit by the most severe drought since 1961. One third of the meteorological stations in Hunan did not observe any effective rainfalls for over 50 days and over 900 km of rivers were fully dried up.⁴³ Frequent floods and droughts significantly impact rice production in Hunan. Therefore, enhancing climate resilience is a priority of

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⁴⁰ Yin, X., Huang, M. and Zou, Y. (2018), Changes in Rice Yield Stability in Southern China from 1949 to 2015. *Agricultural & Environmental Letters*, 3: 170038. ([link](#))

⁴¹ Wang, Z., Shi, P., Zhang, Z. et al (2018). Separating out the influence of climatic trend, fluctuations, and extreme events on crop yield: a case study in Hunan Province, China. *Climate Dynamics* 51, 4469–4487. ([link](#))

⁴² News--6.86 million people and 117 counties and municipalities in Hunan are affected by the floods this year. ([link](#))

⁴³ News--97 of Hunan's 122 counties and municipalities are experiencing extreme drought. ([link](#))

Hunan HSFCP. Meanwhile, following China's carbon peaking commitment, Hunan Province issued the implementation plan for Hunan carbon peaking,⁴⁴ including promoting agricultural mitigation measures, enhancing agricultural GHG accounting and monitoring, and exploring carbon trading. Hunan also issued the implementation plan for emission reduction and carbon sequestration in agricultural and rural sector in 2022.⁴⁵ Rice methane emission represented the largest agricultural GHG emissions in Hunan, accounting for 51 percent of total agricultural GHG emissions.⁴⁶ Thus, rice paddy methane emission reduction was considered as the top priority in the government's agricultural mitigation plan.

30. **Policy and Institutional Reforms in Hunan.** A number of policy reforms have been already started in Hunan, relevant to the Program preparation, including a Comprehensive Agricultural Water Pricing Reform, Sustainability of Irrigation and Drainage Services, Water Right Trading and Buyback, as well as Water User Participation in Irrigation and Drainage Management.

31. **In order to establish and improve the pricing mechanism for agricultural water use, promote water saving and sustainable development of agriculture, a Comprehensive Agricultural Water Pricing Reform has been initiated.** In view of the weak agricultural water conservancy infrastructure, insufficient operation and maintenance funds, unsound agricultural water price formation mechanism, low price level on the whole, and that the role of price lever in promoting water conservation has not been effectively played, which not only results in extensive irrigation water use, but also difficult to ensure the sound operation of farmland water conservancy projects, in 2016, the State Council issued the Opinions on Promoting the Comprehensive Agricultural Water Pricing Reform. It proposes to establish and improve agricultural water pricing mechanism which reasonably covers the cost of water supply, is conducive to water-saving and innovation of farmland water conservancy management systems and mechanisms, and is compatible with the investment and financing systems within about 10 years. In 2019, NDRC, MOF, MWR and MARA jointly issued the Notice on Accelerating the Comprehensive Agricultural Water Pricing Reform. It makes clear the requirements for the establishment of four mechanisms: a pricing mechanism for agricultural water use, a mechanism for targeted subsidies and water-saving incentives, a mechanism for project construction and maintenance, and a mechanism for water use management.

32. **In order to speed up the comprehensive agricultural water pricing reform and ensure the successful completion of the comprehensive reform by 2025, Hunan Province formulated the Implementation Plan for the Categorized and Orderly Promotion of the Comprehensive Agricultural Water Pricing Reform in Hunan Province and began to implement it.** The reform goal is well defined: by 2025, the four mechanisms should be established within the region of irrigation area of the province, to ensure sufficient funding for infrastructure, good operation and maintenance practices, and effective water saving and GHG emission reductions. Fourteen counties, including the proposed Program county of Hanshou, have been selected as demonstration counties for agricultural water price reform in Hunan Province. The Development and Reform Commission of Hunan Province has led the drafting of the Acceptance Measures for the Comprehensive Agricultural Water Pricing Reform in Hunan Province (Draft for Comments), which is seeking comments from relevant departments and will be released soon.

33. **A series of policies and measures to promote the Reform of Irrigation and Drainage Management and the Improvement of Service Capacity has also been initiated.** According to the Regulations on Farmland Water Conservancy promulgated by the State Council in 2016, rural collective

⁴⁴ People's Government of Hunan Province, Implementation plan for carbon peaking in Hunan Province. ([link](#))

⁴⁵ Implementation plan for agricultural and rural sector carbon emission reduction and sequestration in Hunan Province. ([link](#))

⁴⁶ 2020 Hunan provincial GHG emission inventory. Data from Hunan Provincial Department of Ecology and Environment.

economic organizations, farmers' water cooperation organizations, farmers and others are encouraged to carry out the construction, operation and maintenance of farmland water conservancy projects, protect project facilities, save water and protect the ecological environment. The village organizations and contract operators should play main role in project operation and maintenance, and fulfill the responsibility of beneficiaries. It guides and encourages large professional households, family farms and farmers' cooperatives to participate in the daily maintenance of farmland facilities. In 2016, The State Council issued the Opinions on Promoting the Comprehensive Agricultural Water Pricing Reform, which stated that the price of agricultural water should cover the operation and maintenance cost in about 10 years. In addition, many irrigation areas do not charge water fees for water supply and field irrigation and drainage services. Even if in a small number of cases water fees are charged, they can only cover about 20 percent of O&M costs, which tend to be subsidized by local financial funds. At present, the operation and maintenance funds covered by water fee income and financial subsidy funds are up to 80 percent (in Louxing District, Loudi City) which is the largest, and less than 20 percent in most area (Qiyang County, Yongzhou City, and Jiahe County). There is a large gap in irrigation and drainage operation and maintenance funds, which is not fully guaranteed, seriously affecting the benign operation and sustainable irrigation and drainage service. In combination with the comprehensive agricultural water price reform, some counties plan to gradually charge water fees in the next two years (such as Yongzhou City), but the reform progress is slow. It is still a major challenge to ensure the full amount of operation and maintenance funds for irrigation and drainage projects in a long term, and to solve the challenge of poor O&M.

34. The State has introduced a number of policies to support the transfer of water rights and the buyback of saved water use right. In 2016, The State Council issued the Opinions on Promoting the Comprehensive Price Reform of Agricultural Water which proposes to establish the agricultural water rights system. On the basis of the total water use control index of county-level administrative regions, according to the irrigation water quota, the water use index is gradually refined and allocated to the rural collective economic organizations, farmers' water cooperation, farmers and other water users, and the specific water source. The water rights are defined, and the total water use amount is controlled. It encourages users to transfer water-saving amount, which the government or its authorized water administration department or the management organizations of the irrigation area may repurchase. To meet the water demand for agriculture within the region, the transfer of water-saving amount across regions and sectors should be carried out. In 2022, the MWR, NDRC, and MOF issued the Guiding Opinions on Promoting the Reform of Water Rights. In view of problems such as unclear ownership of water rights, inadequate market development, and inactive trading, it is proposed to accelerate the initial allocation of water rights, promote market-oriented trading, improve the trading platform, and strengthen the supervision of water rights trading, to accelerate the establishment of a water rights system with clear ownership, clear rights and responsibilities, smooth circulation, and effective supervision, and to accelerate the construction of a unified national water rights trading market, so as to improve the optimal allocation of water resources and the intensive and economical utilization level, and promote ecological civilization and high-quality development.

35. Hunan Province has assigned the total water consumption target for each city and county in the 14th FYP period, carried out the pilot water rights trading, and water rights trading and saved water rights buyback in some areas. In 2022, the Water Resources Department and the Development and Reform Commission of Hunan Province jointly issued the Notice on the Total Amount and Intensity of Water Use in the 14th FYP period, which determined the total amount of water use control targets for each city and prefecture in 2025. In 2022, the Water Resources Department of Hunan Province issued the Forecast and Distribution Plan of Total Agricultural Water Use at the end of the 14th FYP period in Hunan

Province, which clarified the agricultural water consumption of each city and prefecture under the condition of annual average precipitation in 2025. From 2015 to 2017, a pilot reform of water rights was carried out in Jiangbei Town, Changsha County, and the confirming and registering water rights in different sectors was completed. From 2019 to 2021, the annual saved water right buyback of Tongrenqiao Irrigation District in Changsha County was completed through the National Water rights trading platform for three consecutive years. The proposed Program counties have not yet carried out water rights trading and saved water rights buyback, but encouragingly, during pre-appraisal mission, the project counties showed high enthusiasm for carrying out the water rights trading pilot and exploring the market-oriented incentive mechanism of water saving.

36. Participation of farmers' organizations such as farmers' water users' associations and farmers' cooperative organizations in the management of irrigation and drainage projects is strongly encouraged. In 2005, the MWR, NDRC and the MCA (Ministry of Civil Affairs) jointly issued the Opinions on Strengthening the Construction of WUAs for Farmers, emphasizing the importance of strengthening the construction of WUAs for farmers, putting forward the construction guiding ideology and principles, and clarifying the responsibilities and tasks, construction procedures, operation and capacity building of WUAs for farmers. According to the Regulations on Farmland Water Conservancy promulgated by The State Council in 2016, irrigation and water conservancy projects should be managed by irrigation management organizations in combination with the management of rural collective organizations, farmers' water cooperation and farmers. In 2016, The State Council issued the Guidance on the Comprehensive Agricultural Water Pricing Reform which requires to gradually establish a water-saving incentive mechanism for agricultural water use that is easy to operate and widely accepted by water users. According to the amount of water-saving, large-scale business entities, farmers' water cooperative organizations and farmers who take water-saving measures and adjust planting structure to save water will be rewarded, so as to improve users' awareness and enthusiasm of active water-saving. In 2018, the Law of the People's Republic of China on Specialized Farmers Cooperatives was revised and promulgated to regulate the organization and conduct of specialized farmers cooperatives, support and guide their development, protect the legitimate rights and interests of specialized farmers cooperatives and their members, and promote agricultural and rural modernization.

37. In 2014, Hunan Province issued the Guiding Opinions on Strengthening the Construction of Farmers' WUAs to support the construction of farmers' management organizations such as farmers' WUAs. It clarifies the natures, guiding ideology and basic principles of the construction of farmers' water users' associations, their responsibilities and tasks, and specific establishment procedures, proposes to strengthen the operation and capacity building of the associations, requires governments at all levels to effectively strengthen the development and support of farmers' water users' associations, and appropriately provide funds for project management and operation and maintenance. According to the field investigation during pre-appraisal mission, the development of water cooperative organizations in the project counties varies. In Hanshou County of Changde City which is a demonstration county of water user Cooperation Organization construction in Hunan Province, the development of water use cooperation organizations (water users' associations, agricultural cooperatives, etc.) is relatively good, the irrigation area of paddy fields managed by water use cooperation organizations accounts for more than 65 percent of the total irrigation area of paddy fields in 2021, which is the highest among the project counties. In Dingcheng District of Changde City, the field irrigation and drainage project is mainly maintained and managed by the village collective, and there is no farmer water cooperation organization at present. The proportion of irrigated area under the management of water cooperative organizations in Louxing District of Loudi City, Lukou District of Zhuzhou City, Qiyang County of Yongzhou City and Jiahe County of Chenzhou City ranged from 15 to 31 percent. At present, most water cooperative organizations

do not charge water fees, and the operation and maintenance management of small projects shall be borne by the beneficiary farmers in the way of one-case discussion. The large operation and maintenance management funds shall be applied for county financial subsidies. The operation and maintenance funds of irrigation and drainage projects cannot be effectively guaranteed, and the management capacity of water cooperative organizations is relatively weak.

The Government Program

38. **The Government of China has embarked on reform path, which prioritizes lowering GHG emissions and achieving high resource use efficiency and sustainability of the economic activities. In the agriculture sector, the government has adopted a series of reform documents moving towards green, efficient and sustainable agriculture sector development.** These reform documents provide the overall framework for such development. In 2021, the Government formally launched the *Green Agriculture Development Strategy* to promote green growth and decarbonization in the agricultural sector and systematically address the issues of high GHG emission and pollution, low resource use efficiency and concerns over sustainability of agricultural production and related support services. The overarching goal is to move toward greener, more resilient and sustainable agricultural development. This is expected to be achieved through institutional capacity strengthening, policy reforms and market mechanism pilots, demonstration, consolidation and replication of innovative technologies and good management practices. *China's 14th FYP for Socio-Economic Development* articulates the need to promote green development to achieve harmonious coexistence of man and nature. *The National 14th Five-Year Plan (FYP) for Green Agriculture Development (2021-2025)* supports these goals through targeting increases in land and water resource use efficiency, resource conservation, reduction of agricultural GHG emissions, improving agricultural ecosystems and environmental quality, reduction of chemical fertilizer and pesticide application, and the development of low-carbon agricultural industrial chains as the key goals to be achieved by 2025.⁴⁷

39. On the irrigation and water management side, over the past several decades, the government of China has been rolling out the required policy and regulations promoting irrigation and drainage service management reform (irrigation management reform) along with investment in infrastructure improvement, as an integral part of the irrigation modernization. The *National Water Saving Improvement and Irrigation Modernization Program* for Large and Medium Irrigation Districts is being implemented since 1998. A series of successful pilots of irrigation management reform have been carried out to enable more sustainable irrigation services, through initiatives such as self-managed irrigation and drainage districts (SIDDs) and implementation of participatory irrigation management engaging water user associations (WUAs). Reliable irrigation services together with innovative irrigation technologies and water management practices such as alternating wetting and drying (AWD) are fundamental to the sustainability of low-methane rice production, particularly in the face of changing climate.

40. On October 24, 2021, the Central Committee and the State Council issued the *Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy* as the top-level, overarching green and low carbon transition guidance. The NDC Commits to control methane and nitrous oxide emissions from rice fields.⁴⁸

⁴⁷ <https://www.fas.usda.gov/data/china-plan-for-green-and-sustainable-ag-development>. China: Plan for Green and Sustainable Ag Development. USDA. October 2021

⁴⁸ <http://www.igdp.cn/wp-content/uploads/2022/04/2022-04-21-iGDP-Report-EN-NDC-3.0.pdf>, p10, under "Agriculture"

41. **Recent policy reforms in China have created opportunities to incentivize water saving and low methane rice production.** Promoting water saving and low methane rice production can generate positive externalities of GHG emission reduction, water saving, and water pollution abatement. The country is now widely promoting eco-compensation mechanisms to reward positive (or to reduce negative) environmental externalities.⁴⁹ Market-based eco-compensation mechanisms have been explored, such as carbon market, water right trading, and pollution emission trading, which can be leveraged to promote low-carbon rice transformation. In addition, China launched the irrigation water tariff comprehensive reform program since 2016 to promote water saving.⁵⁰ This program was incorporated into the national HSFCP to enhance the sustainability of O&M. It lays the foundation for irrigation water tariff reform to incentivize water saving, including improving water flow monitoring facilities, establishing irrigation water right system and volumetric water pricing, promoting demand-driven irrigation water management, empowering the capacities of farmers and water user associations (WUAs), and establishing a water-saving reward system.

42. *The National High-Standard Farmland Construction Plan (HSFCP, 2021-2030)* which was issued by the Ministry of Agriculture and Rural Affairs (MARA) of China, is part of the above-described reform package to increase sustainability and greening of the economy, and is the anchor program for this PforR. It is a key priority government investment program for the implementation of the National 14th FYP for Green Agriculture Development. The program supports farmland construction and improvements in sustainable production of the three staple crops, rice, wheat and maize for food security, environmental sustainability, climate resilience. It has a target of constructing 1.2 billion Mu (800 million ha) and reclaiming 280 million Mu (187 million ha) of high-yield, water efficient and eco-friendly high-quality farmland, including paddy by 2030.

43. **Objectives and themes of the National Government program.** The program has the following overall objectives: (1) improve the national grain production capacity; (2) promote transformation and upgrading of agricultural production methods; (3) improve the ecological environment and promote greening of farmlands and (4) broaden channels for farmers to increase their incomes. The program also aims to achieve improvements in the following thematic areas, with specific proposed actions and mandatory and recommended results targets related to each thematic area: (1) Strengthening agricultural resources protection and use efficiency and improving production infrastructure to increase production capacity, specifically: Land Leveling and Consolidation, Soil Improvement, On-farm Access Roads, and Farm Power Supply Facilities; (2) Improving irrigation and drainage systems and water management, specifically On-farm Irrigation & Drainage Facilities; (3) Reducing agricultural NPS pollution and improving production environment, specifically Farm Return Flow Pollution Control, Chemical Fertilizer Use Reduction & Efficiency Improvement, Pesticide Use Reduction & Efficiency Improvement, and Crop Straw Return to Field & Utilization; (4) Enhancing ecological protection and restoration for sustainable production, specifically Farmland Protection & Ecological-Environment Protection Facilities; (5) Promoting green and low-carbon technologies and practices for mitigating climate impacts, specifically Technological Extension Services and Smart Monitoring and Evaluation; and (6) Improving institutions and capacity for O&M and sustainable service, specifically Smart Management of information management and sharing, agricultural water pricing reform, Improving O&M and management system and the standard system, and Promoting agricultural carbon emission reduction and sequestration.

⁴⁹ World Bank. 2022. Ecological Compensation in China: Trends and Opportunities for Incentive-Based Policies Towards a Greener China ([link](#))

⁵⁰ State Council. 2016. Opinions on promoting irrigation water tariff comprehensive reform ([link](#))

44. **The High-Standard Farmland Construction Plan for Hunan Province (Hunan HSFCP) 2021 – 2030 is a Provincial-level program contributing to the overall objectives of the NHSFCP.** Following the guidance of national HSFCP, Hunan issued its provincial HSFCP in June 2022, mainly for the farmlands of rice production.⁵¹ Hunan HSFCP has eight key tasks, including farmlands leveling ('farmlands'), enhancing soil quality and fertility by protecting and improving plough layer, enhancing soil organic matters, lowering shallow groundwater table, improving sandy and clay soil types, and maintaining suitable soil pH ('soil'), improving irrigation and drainage systems by desilting small water storages, and rehabilitating irrigation and drainage facilities to enhance the assurance of irrigation water and the efficiency of drainage, and improving water-saving irrigation facilities ('water'), improving farm roads to meet the needs of agricultural machinery and transport ('road'), improving windbreak to reduce soil erosions and building ecological ditches to reduce pollution ('forest'), improving power supply facilities for agricultural production ('electricity'), promoting good techniques and practices by enhancing agricultural machinery application, applying high quality seeds, promoting soil testing and formula fertilizer application and integrated pest control, and enhancing training for farmers ('technique'), and improving O&M and monitoring ('management').

45. **Hunan Province takes multiple measures to build high-standard farmland and implements the "Hunan Province High-Standard Farmland Construction Plan (2021-2030)".** By the end of 2021, the total high-standard farmland area in the province reached 36.12 million mu (2.41 million ha). With improving of the farmland infrastructure, agricultural production conditions have been improved, and the capacity of farmland disaster prevention, resistance and reduction has been enhanced. After the completion of high-standard farmland, the average comprehensive grain production capacity per ha has increased by more than 10 percent. According to the plan, by 2023, the total high-standard farmland area will reach 41.47 million mu (2.76 million ha), and 1.51 million mu (0.1 million ha) of high-standard farmland will be upgraded. By 2025 and 2030, the total high-standard farmland area will respectively reach 42.98 million mu (2.87 million ha) and 46.43 million mu (3.10 million ha), 4.52 million mu (0.30 million ha) and 12.12 million mu (0.81 million ha) of high-standard farmland will be upgraded. By 2035, through continuous construction and upgrading, the quantity and quality of high-standard farmland in the province will be further improved, farmland infrastructure will be improved, and green farmland, digital farmland and smart farmland will be more mainstreamed, contributing to higher-level, more efficient and more sustainable food security. The county-level targets and execution in the participating counties, both the physical (Table 3) and financial (Tables 4A and 4B) are as follows:

Table 3: Data on the High Standard Farmland Construction Program in the Program Districts and Counties (2021)

County/District	Total agricultural land (for cultivation), ha	Area included in the HSFCP 2021-2030 ha	Area completed to date under the HSFCP, ha
Lukou District	21,460	9,606	3,340
Jiahe County	20,458	9,813	3,786
Qiyang County	46,111	28,273	10,053
Louxing District	13,256	5,846	1,420
Dingcheng District	70,786	34,106	9,833

⁵¹ Around 85 percent of Hunan's farmlands are for rice production and Hunan HSFCP only focuses on the farmlands for major grain production. Hence almost all high-standard farmlands under the Hunan HSFCP are for rice production.

Hanshou County	63,513	27,246	8,819
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Table 4A: Implementation of the HSFCP 2021 -2030 in the Program Counties and Districts – Area and Financing Targets and Execution

County/District	2021 Plan/Execution, ha		2022 Plan/Execution, ha		2023 Plan
	Target, ha	Delivered, ha	Target, ha	Delivered, ha	Target, ha
Lukou District	1840	1840	1500	1500	1153
Jiahe County	1920	1920	1786	1786	920
Qiyang County	4940	4940	5113	5113	4360
Louxing District	660	660	760	760	706
Dingcheng District	5220	5220	4613	4613	5133
Hanshou County	4593	4593	4226	4226	4180

Table 4B: Implementation of the HSFCP 2021 -2030 in the Program Counties and Districts – Financing Targets and Execution

County/District	2021 Financing Plan/Budget Execution, millions CNY (all sources – national, provincial and county budget)		2022 Financing Plan/Budget Execution, millions CNY (all sources – national, provincial and county budget)		2023 Financing Plan, millions CNY (all sources – national, provincial and county budget)
	Total allocated, millions CNY	Total Spent, millions CNY	Total allocated, millions CNY	Total Spent, millions CNY	Total allocated, millions CNY
Lukou District	44.16	44.16	36	36	27.68
Jiahe County	46.08	46.08	42.88	42.88	22.08
Qiyang County	118.56	118.56	122.72	122.72	104.64
Louxing District	15.84	15.84	18.24	18.24	16.96
Dingcheng District	125.28	125.28	110.72	110.72	123.20
Hanshou County	110.24	110.24	101.44	101.44	100.32

46. **With a significant focus on infrastructure under the HSFCP, the probability of irrigation water availability in the paddy area is not less than 90 percent.** Farmland irrigation and drainage projects are scientifically planned, the construction and rehabilitation of water sources, water canals, drainage ditches, and structures are to be carried out orderly. Irrigation and drainage facilities, backbone projects and field projects are implemented in parallel and constructed and rehabilitated in an integrated manner. It also includes construction of irrigation canals (pipes), drainage ditches (pipes), pumping stations and

structures, ecological irrigation and drainage systems. In addition, the program promotes protecting farmland ecological environment, water-saving irrigation technologies such as seepage prevention of channels, water delivery by pipeline, integrated management of water and fertilizer according to local conditions, and practical and feasible water metering facilities to improve the irrigation guarantee rate and flood control and drainage capacity of high-standard farmland.

2.4 The World Bank Financed Program

47. **The PforR Program is anchored in the Hunan HSFCP to achieve win-win outcomes of reducing methane emissions and enhancing resilience for rice production.** The proposed PforR will be implemented at both the provincial and demonstration county levels. The PforR Program will leverage the opportunities in Hunan HSFCP to remove the system constraints for adopting mitigation measures and enhancing resilience, by building more reliable and flexible irrigation and drainage systems, leveling lands, enhancing soil quality and fertility, improving fertilizer and pesticide management, and improving associated high-standard farmland facilities. The Program will bridge the gaps to incorporate the mitigation concepts and measures into Hunan HSFCP, and scale up these measures with comprehensive training programs for farmers. Provincial strategy, guidelines and standards will be developed and issued to guide the implementation of mitigation measures at the county level. The coordination mechanism between agriculture and water sector will be established. The Program will apply the provincial MRV system to track rice GHG emissions, including methane. Agricultural water pricing reform will be implemented to create incentives for saving water and to support sustainable O&M. Carbon trading and water trading mechanisms will be explored and piloted to further financial incentives for farmers to invest and adhere to new water saving and low methane rice production technologies.

48. **The water-straw-fertilizer co-management is conceived as the package solution for methane reducing and climate resilient rice production under this PforR Program.** Based on the scientific research and experiment data, field studies over several decades, farmer consultations and stakeholder engagement, and remote sensing analysis, the water-straw-fertilizer co-management is proposed for the rice production in Hunan Province:

- (i) **Water Management:** This Program promotes optimized AWD with wetting and drying at three rice growing stages — the early stage of rice growing, the late stage of tillering, and the yellow ripening to harvesting stage. Many farmers in Hunan practice drying at the yellow ripening stage to enhance rice resistance to lodging and to facilitate harvesting. Some farmers in Hunan practice drying at the late stage of tillering. The farmers consulted expressed their willingness to begin drying at the late stage of tillering, demonstrating an understanding that drying can increase rice yield and enhance rice resistance to lodging and disease. A very limited number of farmers have practiced drying at the early stage of rice growing before or after transplanting. The water saving practices promoted in the 1990s did not include drying at the early stage of rice growing. However, as straw returning has become widely adopted in Hunan in recent years, the decomposition of fresh straw residues under flooded anerobic conditions at the early rice growing stage significantly increased methane emissions.⁵² Therefore, this Program will also promote drying at the early stage of rice growing to allow straw aerobic decomposition to reduce methane

⁵² Jiang Y. et al., 2019. Acclimation of methane emissions from rice paddy fields in response to straw incorporation. Science Advances, 2019;5. ([link](#))

emissions in rice fields,^{53, 54} while benefiting the development of rice roots and enhancing the resistance to lodging and disease. Dry direct seeding, which usually requires a longer rice growing season, will not be promoted in this Program. Hunan encourages double-cropping rice production to enhance food security. Dry direct seeding is thus not suitable for double-cropping rice in Hunan given the limited rice growing time and tight rotation.

(ii) Straw Management: In addition to the co-management of straw return and drying period, the Program will promote deep returning of straw residues. Returning crop straw and applying green manure to farmlands can raise and stabilize crop yields, improve soil health and fertility, and significantly increase soil carbon sequestration.⁵⁵ However, farmers usually return straw residues within a shallow soil depth (less than 10 cm). The straw decomposition under this shallow soil depth under flooded conditions will increase methane emissions and generate reductive substances (such as hydrogen sulfide) that are toxic for rice roots. The deep returning of straw residues can help further reduce methane emissions, promote rice root development, reduce borer pests, and enhance soil fertility and soil carbon sequestration.

(iii) Fertilizer Management: The application of decomposed organic materials, such as compost, biogas slurry and biogas residues, and commercial organic fertilizers significantly increases soil organic matters without accelerating methane emissions from the rice paddies.⁵⁶ The Program will promote the use of organic fertilizer to enhance soil fertility and carbon sequestration and to reduce the application of chemical fertilizer and nitrous oxide emissions. The Program will also support various soil fertility improvement activities under the Hunan HSFCP, such as fertilizer deep application, straw returning, organic fertilizer, and green manure utilization. In addition, the timing of drying and the methods of fertilizer application will be further optimized to maintain low levels of nitrous oxide emissions during the implementation of AWD.⁵⁷

49. **Six counties were selected to demonstrate water saving and low methane rice production.** These are *Lukou, Jiahe, Qiyang, Louxing, Dingcheng, and Hanshou*,⁵⁸ which represent two most typical rice production regions in Hunan Province:

(a) Dongting Lake Plain Region: The demonstration counties of Dingchen and Hanshou are located in this region. The region is next to the Dongting Lake, the second largest freshwater lake in China. The region has relatively abundant water resources and is threatened by frequent flooding. Surface water irrigation mainly relies on pumping in this region. The groundwater table is shallow, causing water logging and soil gleying issues. Therefore, enhancing resilience to flood events and

⁵³ Hang X. et al., 2014. Differences in rice yield and CH₄ and N₂O emissions among mechanical planting methods with straw incorporation in Jianghuai area, China. *Soil and Tillage Research* 144, 205-210

⁵⁴ Linquist B. A. et al., 2015. Reducing greenhouse gas emissions, water use, and grain arsenic levels in rice systems. *Global Change Biology*. 21, 407-417. ([link](#))

⁵⁵ Lal R., 2004. Soil carbon sequestration impacts on global climate change and food security. *Science*, 304(11): 1623-1627. ([link](#))

⁵⁶ Feng J. et al., 2013. Impacts of cropping practices on yield-scaled greenhouse gas emissions from rice fields in China: A meta-analysis. *Agriculture, Ecosystems & Environment* 164, 220-228. ([link](#))

⁵⁷ Jiang Y. et al., 2019. Water management to mitigate the global warming potential of rice systems: A global meta-analysis. *Field Crops Research* ([link](#)). Jiang et al. 2019 found that, on average, AWD increases the emissions of nitrous oxide by 105 percent. However, the overall nitrous oxide emission is low and contributes to around 12 percent of the GWP. The increased GWP from higher nitrous oxide emissions is much lower than the decreased GWP through the reduction of methane emissions.

⁵⁸ Seven demonstration counties are selected following a set of criteria, including that i) the counties should have solid HSFCPs and a large area of surface water irrigated rice farmlands; ii) the selected investments should have significant economic, social and environmental benefits; iii) the counties should have strong commitments and willingness to adopt new technologies, and explore pilots and institutional reform; iv) the counties should relatively strong program management team with the support of technical experts; v) the county governments have enough lending capacity and willingness to apply the International Bank for Reconstruction and Development (IBRD) Loan; and vi) the counties do not have similar on-going projects supported by international loans.

improving drainage are the priorities for this region in Hunan HSFCP; and

- (b) **Hilly Region:** The demonstration counties of Lukou, Jiahe, Qiyang and Louxing are in this region. The region has the largest farmland areas in Hunan. It has a complex topography with undulating low hills. Water resources distribution is uneven, with high risks of both floods and droughts. The improvement of small water storages can either handle the irrigation needs for small farmland areas or supplement irrigation from other sources. The improvement of irrigation and drainage facilities can better distribute water during droughts and drain water efficiently during floods. Thus, enhancing climate resilience to floods and droughts are the priorities for this region in Hunan HSFCP. The proposed PforR Program will support these priorities identified in Hunan HSFCP, while further scaling up the mitigation actions with the HSFCP.

50. **The PforR Program will strengthen the government management system for water saving and low methane rice production (Results Area 1).** The Program will address the institutional constraints to guide and coordinate mitigation actions. The Program will develop and issue a series of strategies, standards and guiding documents—i) The provincial strategy and implementation plan will be developed and issued to guide implementation and knowledge dissemination of water saving and low methane rice production over medium- and long-term; ii) The integrated provincial technical standards will be developed and issued to provide detailed guidance on the water-straw-fertilizer co-management measures based on different local contexts; iii) The irrigation water quota for rice production will be updated and issued to incorporate the quotas of water saving techniques based on typical local conditions; and iv) The provincial guiding document on water right trading will be issued to guide the implementation of water right trading to reward water saving from rice production. The Program will establish and strengthen agriculture and water coordination mechanisms and promote data sharing at the county level to further bridge the institutional gaps. The Program will also address the information gaps. A parallel PforR Program scheduled for Board approval in April 2023, - Green Agriculture and Rural Revitalization PforR for Hubei and Hunan (GARR (Hubei and Hunan)), plans to develop the MRV methodology for rice paddy before 2025. Built upon the MRV methodology developed in GARR (Hubei and Hunan), this Program will adopt and apply this MRV to measure, report and verify rice GHG emissions in the selected counties, which will also support the carbon trading pilots in these counties. A monitoring network will be established with both remote sensing and in-situ measurements. Remote sensing technology will be explored to measure methane emissions at large scale, as well as other factors impacting rice GHG emissions, such as rice production areas, rotation practices, and rice water practices. In-situ ground monitoring will be established to directly measure rice GHG emissions, as well as the impacting factors of climate, soil types, fertilizer and straw management practices, and other agronomic practices. The MRV system will generate lessons to monitor the implementation of rice mitigation actions, and assess their GHG effects, especially methane reduction effects.

51. **The PforR Program will support the mitigation actions to reduce GHG emissions for low-methane development (Results Area 2).** The Program will remove the system constraints for adopting mitigation measures by supporting the selected key activities in Hunan HSFCP, including the construction and rehabilitation of irrigation and drainage systems, the improvement of small water storages,⁵⁹ land

⁵⁹ The PforR Program will only support the development and rehabilitation of small water storages, such as rainwater harvesting systems and ponds. Large dam construction and rehabilitation are excluded from the PforR. The rehabilitation and improvement of large dams are implemented under another national program of Dam Rehabilitation and Improvement Program, led by water sector. The construction and rehabilitation of headworks, primary and secondary canals are implemented under the national program of Large and Medium Irrigation District Upgrading and Water Saving Improvement Program, which is also led by water sector. These programs will provide more reliable water supply for irrigation. The HSFCP only include the development and rehabilitation of on-farm facilities, such as small water storages, which will further improve the reliability of irrigation water

levelling, the improvement of soil quality and fertility, as well as the development of high-standard farmland associated facilities such as on-farm access roads, and on-farm windbreak shelter forests and grasses. These interventions will provide flexible irrigation and drainage services with reliable water supply, and well-leveled farmlands with the suitable size for irrigation, drainage and machinery application, which will create the basic foundation for adopting mitigation measures and enhance yields. The Program will introduce and scale up mitigation measures with Hunan HSFCP. The key package of solutions of water-straw-fertilizer co-management will be promoted and scaled up with comprehensive training programs. Carbon trading is considered as one of the incentive mechanisms for farmers to adopt mitigation measures. China has its voluntary carbon market, the China Certified Emission Reduction (CCER),⁶⁰ for rice carbon trading. However, the CCER has been suspended since 2017. Recent new movements are moving towards the relaunch of CCER. The China Beijing Green Exchange (CBGEX),⁶¹ a professional market platform that integrates various environmental trading services, was launched in Beijing on February 6, 2023, one step closer to the relaunch of CCER.^{62, 63} Some provinces are also exploring carbon trading pilots on rice methane emission reduction, such as Fujian Province.⁶⁴ The Program will explore carbon trading mechanism, develop and apply MRV system to track rice GHG emission reduction, and pilot carbon trading in three selected counties.

52. The PforR Program will support the adaptation interventions to provide sustainable irrigation and drainage services for climate resilient rice production (Results Area 3). Built upon the improved irrigation and drainage infrastructure, the Program will further address the constraints for sustainable O&M. The Program will support the implementation of Comprehensive Agricultural Water Tariff Reform, which is a national program launched by the State Council since 2016⁶⁵ and has been incorporated into the HSFCPs as the key O&M mechanism. The Program will audit O&M cost for each irrigation district, establish water pricing mechanism based on cost auditing, develop water-saving reward mechanism, establish precise subsidy mechanism, improve water flow measurement facilities, and develop water use management mechanism. The O&M cost of irrigation water supply will be reasonably covered by the collected water tariff and budget support/subsidy. Thus, precise subsidy mechanism will be established to ensure that sufficient budget support/subsidy would be allocated for O&M. Agricultural water tariff reform is also considered as one of the incentive mechanisms to raise farmer awareness to save water and adopt water saving technologies, such as AWD. It will be combined with water-saving reward strategies that farmers will be charged higher tariff if they exceed water quota, while they will be rewarded if they use less water than the quota. The Program will strengthen the capacity of farmer cooperative organizations (including WUAs) and empower women participation and leadership, in order to enhance the farmer participatory management of irrigation and drainage services. With the improved infrastructure, reformed agricultural water tariff, enhanced farmer organization capacity, and increased tariff collection and precise financial subsidy for O&M cost recovery, the demonstration counties are

supply. The coordination between agriculture and water sector can ensure that the development of high-standard farmlands will well align with the development of large water storage, headworks and main canals to provide reliable irrigation and drainage services.

⁶⁰ CCER Platform ([link](#)). CCER scheme focuses on the voluntary GHG emission reduction transactions, such as the GHG emission reductions from renewable energy, forestry carbon sink, methane reduction and utilization. CCER used to apply CDM methodology ([link](#)) to quantitatively verify and register the credits of rice methane reduction through better water management.

⁶¹ Green exchange launched in Beijing's sub-center. ([link](#))

⁶² Beijing municipal authorities are planning to build a national trading center for China Certified Emission Reduction, or CCER, as part of the city's efforts to further cut carbon emissions and achieve renewable energy goals. ([link](#))

⁶³ Beijing to Construct Chinese Certified Emission Reduction Trading Center. ([link](#))

⁶⁴ In July 2022, Fujian completed one case of carbon trading the methane emission reduction from rice paddies due to the adoption of AWD. ([link](#))

⁶⁵ State Council. 2016. Opinions on promoting agricultural water tariff comprehensive reform ([link](#))

expected to provide sustainable irrigation and drainage services for climate resilient rice production. In addition, water right trading is also considered as one of the incentive mechanisms for farmers to adopt water saving technologies. Hunan has piloted water right trading and government buying-back in several counties. The Program will explore water right trading mechanism, improve trading rules, develop monitoring networks, and pilot water right trading in three selected counties.

53. Targeted training and extension service will be provided to support farmers to adopt the package of mitigation and adaptation solutions. Farmers need extensive training and capacity building to adopt and fully master the mitigation measures. In addition to farmer training and extension services, the Program will also support public awareness raising and information campaigns on the available new technologies and practices, to ensure uptake and mainstreaming of the new technologies.

54. Training will be provided to smallholder farmers, as well as professional farmers, farmer cooperatives, farmer associations, family farms, and agro-enterprises. Targeted training and capacity building will be provided to women to address the gender gaps, encourage women participation, and empower women's decision making. Local Women's Federation will be engaged to carry out targeted training for women. The Program also aims to support establishment of a number of training platforms, such as the demonstration farmlands, on-farm learning schools, and new agricultural business entity demonstration platforms. Demonstration farmlands should be less than 1 ha. with the application of water-straw-fertilizer co-management measures. Comprehensive training formats will be used, such as course teaching and workshops, on-farm training and practicing, online learning and live streaming. On-farm training and practicing is mandatory for each participant. Regulatory instruments and training mechanisms will also be developed and issued to ensure sustainable, long-term trainings. "Top-down" approaches will be used, including issuing technical guidelines to guide the application of mitigation measures, developing annual training work plans, coordinating with the high-competency farmer training program and other farmer training programs in Hunan, and ensuring specific budgets allocated for trainings. "Bottom-up" approaches will also be applied, including carrying out surveys to understand farmer's training needs annually, developing training curriculum and materials according to local conditions, preparing annual training implementation plans, and conducting monitoring and evaluation (M&E) to track training outcomes. In addition, as adopting mitigation measures needs the application of agricultural machinery, extension service systems will be strengthened. Government-administrated agricultural machinery centers are responsible for the subsidy of machinery purchasing, while agricultural machinery service stations will provide affordable agricultural machinery services to farmers to support their mitigation measures.

Table 5. Overview of the Government Program and PforR: Results Areas and Key Activities

Description	Government program <i>Hunan High-Standard Farmland Construction Plan (Hunan HSFCP, 2021-2030)</i>	Program supported by the PforR <i>Anchored in Hunan HSFCP</i>
Objective	To ensure food security and enhance agricultural productivity and resilience	To strengthen methane reduction and climate resilient rice production in Hunan Province
Duration	2021-2030	2024-2028
Geographic coverage	Hunan Province	Hunan Province and six demonstration counties within Hunan
RAs / Activities	The Government program covers eight key tasks as follows:	The PforR will support selected activities of Hunan HSFCP under the following three RAs:

	• Farmland: Land leveling • Soil: Enhancing soil quality and fertility • Water: Improving irrigation and drainage systems and small water storage systems • Road: Improving farm roads • Forest: Improving windbreak and building ecological ditches • Electricity: Improving on-farm power supply facilities for agricultural production • Technology: Promoting good technologies and management practices, and enhancing training and capacity building • Management: Improving O&M and monitoring.	• RA1: Strengthening government management systems for sustainable development impacts • RA2: Reducing GHG emissions for low-methane development • RA3: Improving irrigation and drainage services for climate resilient rice production
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55. The Hunan HSFCP provides opportunities to promote and scale up water saving and low methane rice production, specifically:

- (a) **Infrastructure Improvement.** Hunan HSFCP heavily focuses on infrastructure investment. Majority of the investments are water-related, such as the improvement of small water storages and irrigation and drainage systems, which account for 70 to 80 percent of the total investment costs. These investments will provide flexible irrigation and drainage services with reliable water sources, which will lay a solid foundation to adopt water saving techniques, such as AWD. Other investments, such as upgrading of irrigation and drainage systems, will also create the favorable conditions to further adopt water saving techniques.
- (b) **Yield Enhancement.** Through a combination of irrigation and agricultural solutions, the Hunan HSFCP expects to mitigate the potential negative impacts of adoption of mitigation measures on rice yields, which is a key concern. Hunan HSFCP will significantly improve irrigation and drainage systems to make rice production more resilient to floods and droughts. The improvement of soil quality and fertility, and adoption of smart agriculture measures, will further improve rice yields. The construction of high-standard farmlands will allow the application of modern agricultural machinery to increase the efficiency and yields of rice production. Combining the well-designed mitigation measures with these interventions will reduce GHG emissions while increasing, or, at a minimum, maintaining yields.

56. The Government program of Hunan HSFCP provides opportunities to address the institutional challenge of strengthening the enabling environment for low methane and water saving rice production:

- (a) **Guiding documents, regulations and technical standards:** The national HSFCP encourages the provinces to issue related provincial/local guiding documents and standards. Hunan has not yet issued dedicated strategies, regulations or standards related to water saving and low methane rice production. Current water, straw and fertilizer management practices promoted in Hunan do not consider the synergies and interactions among the factors affecting GHG emissions (see Section II. C. and Annex 3). The current water quota for rice irrigation in Hunan only considers the water quota of traditional flood irrigation, which should be updated to promote water saving technologies. A

dedicated provincial strategic and regulatory framework is needed to incentivize water saving and low methane rice production. Although water rights trading had been piloted in the Hunan province, a document guiding implementation on water rights trading is needed to guide and regulate the water market and to reward the positive externalities of water saving;

- (b) **Data constraints:** The Hunan HSFCP requires the establishment of an information system and monitoring networks to track high-standard farmland construction, which can be expanded to include the in-situ measurements of rice GHG emissions. A national MRV standard for rice will be developed under the China Green Agricultural and Rural Revitalization Program for Results (Hubei and Hunan) - (P178907, hereafter, GARR [Hubei and Hunan]). The national MRV standard can be adopted and applied in Hunan to track rice GHG emissions and guide rice carbon trading;
- (c) **Coordination between the Agriculture and Water Sectors:** The HSFCP highlights the importance of the coordination between the agriculture and water sectors. The main irrigation system is managed by the water sector, including the headworks and primary and secondary canals, which are very important for reliable and flexible irrigation services for AWD application. Good coordination between the agriculture and water sectors can ensure that the development and O&M of high-standard farmlands are well aligned with those of the main irrigation systems for the effective functioning of the entire irrigation and drainage system. The agriculture and water sectors in Hunan have established an initial coordination mechanism for planning purposes. But these mechanisms have not been formalized and the collaboration between the two sectors should be extended beyond infrastructure development to include data sharing and O&M for related service delivery.

57. **For farmers, the Government program of Hunan HSFCP provides opportunities to address their challenges in adopting water saving and low methane rice practices:**

- (a) **System constraints:** The Hunan HSFCP focuses on resilience-related infrastructure investments. The improvement of irrigation and drainage systems and small water storages accounts for 70 to 80 percent of the total investment costs. These investments will help remove the system constraints for flexible irrigation and drainage services with reliable water sources, which will lay the foundation for adopting water saving technologies to reduce rice methane emissions. The Hunan HSFCP also promotes soil fertility improvement practices and the application of modern agricultural machinery, which will improve rice yields and can further reduce GHGs and enhance soil carbon sequestration. It was estimated that the construction financed under the HSFCP will increase yields by 10 to 15 percent. However, as stated in the Hunan HSFCP, the province faces big challenges related to O&M. Without sustainable O&M, the irrigation and drainage infrastructure will deteriorate quickly, as evidenced by the large area of high-standard farmland constructed from the 2010s that already needs to be rehabilitated and upgraded. Hunan HSFCP considers agricultural water tariff reform a key mechanism for reaching O&M cost recovery. The capacity of farmer cooperative organizations (including WUAs) also needs to be strengthened to better fulfill their O&M responsibilities.
- (b) **Financial incentives:** Supporting the implementation of the HSFCP and promoting climate change mitigation measures will reduce losses from climate extremes, save production costs and increase yields (see Section IV and Annex 3). Farmers also have a good understanding of the importance of AWD on improving rice production (see Box 2 and Farmer consultation in Section IV. A). Besides these essential benefits, agricultural water pricing reform can be leveraged to create incentives to save water and further promote the adoption of water saving technologies. Mechanisms for water tariff reform and water saving rewards in Hunan are under development, and the collection rate of the agricultural water tariff is still low. Market-based mechanisms, such as water rights trading and carbon trading, can be explored to generate additional incentives. Water rights trading has been piloted in several irrigation districts in Hunan since 2015 to continue rewarding the positive

externalities of saving water. The trading mechanisms require further improvement. Although some carbon trading pilots on rice methane emission reduction have been carried out in China,⁶⁶ Hunan has not conducted carbon trading in the agricultural sector.

- (c) **Capacity building and empowerment:** The Hunan HSFCP provides support for training farmers and promotes good practices. However, capacity building is not thoroughly addressed. As a result, after the construction of high-standard farmlands, many farmers continue using traditional, inefficient water and fertilizer practices, and thus do not maximize potential yield increases. In addition, water saving technologies, the key climate mitigation measures, were not included in the Hunan HSFCP. Farmer consultation and stakeholder engagement also revealed that farmers lack technical guidance on integrated water-straw-fertilizer practices. Hunan has a wide training and extension service network (see Annex 3). There are important opportunities to embed climate mitigation measures in the Hunan HSFCP and leverage the training system to maximize climate mitigation results. Targeted training and capacity building should be provided to women to address the gender gaps.

58. **PforR Program Boundary Definition.** While overall supporting Hunan HSFCP, the PforR will focus on a sub-set of results and geographic areas, drawn from the government program.

⁶⁶ In July 2022, one case of carbon trading on rice methane emission reduction in China was completed in the Fujian Province. It traded the methane emission reduction from rice paddies due to the adoption of AWD. ([link](#))

Table 6. Government Program and PforR Program (Activity) Boundary

Government Program: Hunan High-standards Farmland Construction Plan (2021-2030)			PforR Program Boundary		Reason for Exclusion
Theme	Activity Type	Typical Activities at Provincial and (6) County Levels (2023-2028)	Included or Not	Related PforR Results Area and Activity	
(1) Strengthening agricultural resources protection and use efficiency and improving production infrastructure to increase production capacity	Land Leveling and Consolidation	Large scale land pooling and consolidation for relative concentration of arable land.	None	None	High potential E&S risk
		Levelling land, including stripping topsoil, deep excavation to loosen the soil, backfilling the topsoil to balance the earthwork, compaction field base to improve farmland soil fertility with ridge diked for easy irrigation and drainage. For example: In the 6 demonstration counties, about 40,000 mu paddy field will be levelled during the 14th FYP period.	Same as the left column	RA2(1): Investing in high standard farmland construction in demonstration counties, Improving climate resilience	
	Soil Improvement	Any activities on polluted soil in cultivated land.	None	None	High potential E&S risk
		Improving poor soil structure and increasing soil organic matters by means of thickening tillage, test-based scientific fertilization, planting green fertilizer, retuning crops' straw to the field, and improving tillage method and so on. For example, in the 6 demonstration counties, farmland soil will be improved according to their respective soil conditions during the 14th FYP period;	Same as the left column	RA2 (1): Investing in high standard farmland construction in demonstration counties, Improving climate resilience;	

Government Program: Hunan High-standards Farmland Construction Plan (2021-2030)			PforR Program Boundary		Reason for Exclusion
Theme	Activity Type	Typical Activities at Provincial and (6) County Levels (2023-2028)	Included or Not	Related PforR Results Area and Activity	
		Jiahe County: 14,370 mu of farmland will be fertilized with soil improved in 134 villages of 15 towns/townships during the 14th FYP period; Louxing District: farmland soil improvement will be carried out during the 14th FYP period; Hanshou County: 25,060 mu of farmland soil will be improved in 17 administration villages during the 14th FYP period.		Promoting farmland carbon sequestration;	
	On-farm Access Road	Optimal planning in harmony with water system, irrigation and drainage system and the field ridges and improving on-farm access road, including tractor-ploughed roads, crops production roads, and ancillary facilities for farm machineries to access to the field. For example: In the 6 demonstration counties: 320 km of crop production roads and 360 km of tractor-ploughing roads will be rehabilitated or upgraded during the 14th FYP period, etc.	Same as the left column		
	Farm Power Supply Facility	Providing power support for pumping stations, machinery wells and information engineering, including the required strong and weak current transmission lines, transformer and distribution devices and other facilities	None	None	Not a PforR priority

Government Program: Hunan High-standards Farmland Construction Plan (2021-2030)			PforR Program Boundary		Reason for Exclusion
Theme	Activity Type	Typical Activities at Provincial and (6) County Levels (2023-2028)	Included or Not	Related PforR Results Area and Activity	
(2) Improving irrigation and drainage systems and water management	On-farm Irrigation & Drainage Facility	Developing on-farm irrigation & drainage system required for the high standard farmland (paddy field) and providing high-efficient water-saving facilities, small-scale village-to-township level irrigation facilities (e.g. water storage ponds and ungated weirs for irrigation), drainage pumping stations; Lining the canals/ditches and installing water pipelines, etc.; Implementing alternate wetting and drying (AWD) irrigation measures; Establishing demonstration bases for intelligent water-saving system by applying crop models that analysis water demand for rice production, estimate irrigation water volume to instruct the automatic sluice gates for paddy irrigation. For example: In the 6 demonstration counties, 16 demonstration bases covering total area of 3200 hectares of intelligent water-saving system will be established (two bases for each county and 200 ha for each base) during the 14th FYP period.	Same as the left column	RA2 (1) Investing in high standard farmland construction in demonstration counties, RA (3) Promoting adoption of alternate wetting & drying (ADW) irrigation technology. Improving climate resilience. RA 3. Improving irrigation and drainage services for resilient rice production	
(3) Reducing agricultural NPS pollution and improving production environment	Farm Return Flow Pollution Control	Constructing bio-ditches to reduce the non-point pollution from farming runoff. For example: In the 6 demonstration counties, in combining with irrigation and drainage canal systems, bio-ditches will be constructed to intercept and reduce the impact of nitrogen and phosphorus pollution from farming runoff on environment during the 14th FYP period, etc.	Same as the left column	RA2 (1) Investing in high standard farmland construction in demonstration counties	
	Chemical Fertilizer Use Reduction & Efficiency Improvement	Implementing test-based fertilization and expanding the use of formula fertilizer and organic fertilizers (incorporated with the activity type of technological extension services). For example:	Same as the left column	RA 2 (4) Support efficient fertilizer application and appropriate returning of crop straw to rice field;	

Government Program: Hunan High-standards Farmland Construction Plan (2021-2030)			PforR Program Boundary		Reason for Exclusion
Theme	Activity Type	Typical Activities at Provincial and (6) County Levels (2023-2028)	Included or Not	Related PforR Results Area and Activity	
		In the 6 demonstration counties, test-based fertilization technology will be applied of over 10,000 hectares during the 14th FYP period, etc.		Reduce GHG emission	
	Pesticide Use Reduction & Efficiency Improvement	Reducing the use of chemical pesticides and carrying out comprehensive green prevention and control of diseases and pests through physical and biological measures. Providing precise and specialized pests control services timely (incorporated with the activity type of technological extension services).	None	None	Not a PforR priority
	Crop Straw Return to Field & Utilization	Strengthening multipurpose utilization of crops straws (used as livestock fodders, culture base for mushroom cultivation, building materials, bio-mass fuels, etc.)	None	None	Not a PforR priority
		Promoting fertilizer utilization technologies, such as straw returning to field (incorporated with the activity type of technological extension services). For example: In the 6 demonstration counties, advanced straw returning to field technologies will be applied over 10,000 hectares of farmland during the 14th FYP, etc.	Same as the left column	RA 2 (4) Support efficient fertilizer application and appropriate returning of crop straw to rice field; Promoting farmland carbon sequestration;	
(4) Enhancing ecological protection and restoration for sustainable production	Farmland Protection & Ecological-Environment Protection Facility	Constructing on-farm windbreak (such as shelter forest/grasses on terrace ridges, stream/river banks and slopes, road sides, canal/ditch sides); In the areas prone to soil erosion, reasonable construction of bank slope protection, taking actions for gully erosion control, field barrier protection etc., and repairing damaged farmland. For example:	Same as the left column	RA2 (1) Investing in high standard farmland construction in demonstration counties	

Government Program: Hunan High-standards Farmland Construction Plan (2021-2030)			PforR Program Boundary		Reason for Exclusion
Theme	Activity Type	Typical Activities at Provincial and (6) County Levels (2023-2028)	Included or Not	Related PforR Results Area and Activity	
		In the 6 demonstration counties, shelter forest will be established to cover total area of 5440 mu and an area of 4,000 mu will be covered by ecological grass planting during the 14th FYP, etc.		Promoting farmland carbon sequestration;	
(5) Promoting green and low-carbon technologies and practices for mitigating climate impacts	Technological Extension Services	Advancing the application of digital agriculture, smart irrigation of paddy field and green prevention and control technologies. For example, In the 6 demonstration counties, it is planned to advance the application of green prevention and control technology on the 3200 hectares of the intelligent water-saving systems: e.g., smart spore traps, smart pest forecast lights, smart gyplure (sex attractant) monitors, etc., will be used to monitor, forecast and control occurrence of rice disease and pests to minimize the use of chemical pesticides, while ensuring the increase of rice yield during the Program implementation; Gyplure will be widely applied and solar-powered insect killing lamps will be purchased to serve for more than 5,000 hectares of paddy field, etc.	Same as the left column	RA2 (1) Investing in high standard farmland construction in demonstration counties RA2 (2) Organizing farmer training on low-carbon rice cropping package/ technologies RA2 (3) Promoting adoption of alternate wetting & drying (ADW) irrigation technology	
		Modern farmers training: during the Program implementation, farmers from cooperation, family farms, large planters of the 6 demonstration counties and the peripheral areas will be provided with trainings on practical agricultural techniques and new technologies. Training courses will include, but not limited to, climate-smart agricultural techniques for rice production, such as (1) selection of rice varieties with high yield and low emission, (2) formula fertilization, (3) use of aerobic tillage and aerated cultivation, (4) use of water-saving irrigation technology, (5) implementation of green prevention and control of diseases and pests, (6) high quality straw returning to the field; other practical	Same as the left column	RA2 (4) Support efficient fertilizer application and appropriate returning of crop straw to rice field Reducing GHG emission and Promoting farmland carbon sequestration;	

Government Program: Hunan High-standards Farmland Construction Plan (2021-2030)			PforR Program Boundary		Reason for Exclusion
Theme	Activity Type	Typical Activities at Provincial and (6) County Levels (2023-2028)	Included or Not	Related PforR Results Area and Activity	
		technologies related to agricultural machinery operation, drone operation, information technology, etc. Management trainings: during the Program implementation, trainings will be provided to staff engaged in managing the Program implementation, including the Program management and operation, establishment and management of intelligent agricultural system, management of agricultural carbon reduction and carbon trading, etc.			
		Popularizing the application of scientific fertilization technology, AWD irrigation technology, water-controlled irrigation technology, etc. For example: In the 6 demonstration counties, above-mentioned technologies will be widely popularized during the 14th FYP.	Same as the left column	RA2 (3) Promoting adoption of ADW irrigation technology; RA2 (4) Supporting efficient fertilizer application and appropriate returning of crop straw to rice field; Promoting farmland carbon sequestration	
		Promoting low-emission varieties and advanced straw returning to field technologies (improved varieties and methods), etc. For example: In the 6 demonstration counties, advanced straw returning to field technology will be widely promoted during the 14 th FYP.	Same as the left column	RA2 (4) Supporting efficient fertilizer application and appropriate returning of crop straw to rice field; Promoting farmland carbon sequestration	

Government Program: Hunan High-standards Farmland Construction Plan (2021-2030)			PforR Program Boundary		Reason for Exclusion
Theme	Activity Type	Typical Activities at Provincial and (6) County Levels (2023-2028)	Included or Not	Related PforR Results Area and Activity	
		Equipping with new agricultural machinery equipment and facilities, deepening the integration of agricultural machinery and agricultural technology. For example: In the 6 demonstration counties during the Program implementation, it is planned to (1) install on-farm water level indicators, Tada intelligent control valves on branch canals and lateral ditches, (2) install agricultural environment meteorological detectors, Intelligent insect warning lights, Intelligent automatic monitoring, etc., and (3) establish agricultural machinery service centers (one center for each county), etc.	Same as the left column	RA2(3) Promoting AWD technology and integrated water and nutrient management; Reduce carbon emission	
	Smart Monitoring and Evaluation	Establishing the paddy investment results M&E system and conducting monitoring, evaluation and reporting for carbon sequestration and GHG emission reduction from rice production. For example At Hunan Provincial level, a monitoring, reporting and verification (MRV) standard will be established during the Program implementation. In the 6 demonstration counties, monitoring and evaluation of carbon sequestration and emission reduction in rice production will be carried out during the Program implementation, etc.		RA2 (1) Investing in high standard farmland construction in demonstration counties	
(6) Improving institutions and capacity for O&M and	Smart Management	Strengthening information management and sharing. Results of high standard farmland construction will be integrated into the "one map" of land and resources remote sensing, the regulatory platform of the Ministry of Land and Resource, and subject to on-	Same as the left column	RA1 Strengthening government management system for sustainable development impacts	

Government Program: Hunan High-standards Farmland Construction Plan (2021-2030)			PforR Program Boundary		Reason for Exclusion
Theme	Activity Type	Typical Activities at Provincial and (6) County Levels (2023-2028)	Included or Not	Related PforR Results Area and Activity	
sustainable services.		line monitoring & supervision and unified evaluation and assessment. For example: At Hunan Provincial level, a M&E system and information platform for high-standards farmland construction investment will be established during the Program implementation, etc.			
		Advancing comprehensive agricultural water pricing reform. During the Program implementation, it is planned to be in line with the relevant national policies on promoting comprehensive agricultural water pricing reform and targeting water organization to formulate water price policies based on the actual situation of Hunan Province. A water supply metering system will be established, a precise subsidy and water-saving incentive mechanism will be improved. Based on water price affordability analysis, plan for adjusting water price scientifically will be formulated and agricultural water price mechanism will be advanced to promote water-saving and sustainable development of agriculture. For example: At Hunan Provincial level and in the 6 demonstration counties, a comprehensive agricultural water pricing reform will be carried out. The pilot county of water rights trading/buyback will be determined after the Program county self-declaration and PPMO's study and confirmation. Hanshou County, it is planned during the 14-5 FYP to carry out agricultural water pricing reform in Yanma irrigation district, covering 5 towns/townships and 3 sub-districts, and in Xihu irrigation district, covering 4 towns/townships, for the purpose of	Same as the left column	RA1 Strengthening government management system for sustainable development impact AR3: Improving irrigation and drainage services for resilient rice production	

Government Program: Hunan High-standards Farmland Construction Plan (2021-2030)			PforR Program Boundary		Reason for Exclusion
Theme	Activity Type	Typical Activities at Provincial and (6) County Levels (2023-2028)	Included or Not	Related PforR Results Area and Activity	
		establishing a reasonable water pricing mechanism, a precise subsidy and a reward incentive mechanism for water-saving in agriculture, establishing agricultural water right and small water-saving project property right system reform, as well as management and protection mechanism, etc.			
		Improving operation & maintenance and management system and the standard system. For example: At Hunan Provincial level and in the 6 demonstration counties, it is planned to (1) Improve the management system for water-saving and low-carbon rice production, including establishing new/revising guiding documents; (2) Develop/issue a provincial technical standards for water-saving and low-carbon rice production, (3) Establish a provincial MRV standard for carbon sequestration and GHG emission reduction from rice production, (4) Develop/issue a water-saving and low-carbon rice production replication plan, (5) strengthen farmer water users' participation in managing irrigation area, (6) achieve sustainable irrigation and drainage services, and (7) pilot carbon trading and water right trading or buy-back during the Program implementation. Hanshou County: it is planned during the 14-5 FYP to carry out standardized management on the construction of irrigation areas, including management of high standard farmland construction, safety, water right and other agricultural economic development, etc.	Same as the left column	RA1 Strengthening government management system for sustainable development impact RA3: Improving irrigation and drainage services for resilient rice production	

Government Program: Hunan High-standards Farmland Construction Plan (2021-2030)			PforR Program Boundary		Reason for Exclusion
Theme	Activity Type	Typical Activities at Provincial and (6) County Levels (2023-2028)	Included or Not	Related PforR Results Area and Activity	
		Promoting agricultural carbon emission reduction and sequestration, and planning to carry out pilot carbon trading during the implementation of the Program	Same as the left column	RA1 Strengthening government management system for sustainable development impact; RA2 Reducing GHG emissions for low-carbon development.	

59. **Program financing.** Based on the expenditure framework assessment (EFA), total program financing over the fiscal year (FY) 2024 to 2029 is expected to be US\$1,243 million equivalent, of which US\$988 million (79.0 percent) are expected to be financed by the Government and US\$255 million (21.0 percent) by the IBRD Loan.

Table 7: Overview of Program Financing

Source	Amount (USD Million)	% of Total
Government	988.00	79.0
IBRD	255.00	21.0
Total Program Financing	1,243.00	100.0

60. **Global Public Goods ensured by the Program.** The Program is expected to contribute to a number of global public goods (GPG): reduce methane emissions, promote global knowledge on low methane agriculture development, contribute to biodiversity preservation, and support food security.

61. **Methane emission reductions.** The Program is expected to significantly reduce methane emissions from rice paddy in the Program Province. The Program will widely promote water saving techniques, which are able to substantially reduce methane emission. Besides water saving techniques, a package of agricultural solutions will also be applied to further reduce methane emissions from rice, including the solutions of improved fertilizer management (the reduction of chemical fertilizer use, the increases in organic fertilizer and green manure use, and better co-management of water and fertilizer regimes), improved straw management (the reduction of straw burning, and better straw residue returning strategy), enhanced soil fertility and soil carbon sequestration, optimal rice varietal selection and improved agricultural machinery management. The Program is also expected to generate substantial climate co-benefits by implementing climate adaptation measures, such as improving irrigation and drainage systems to ensure irrigation during droughts and to reduce waterlogging during floods and timely application of fertilizer to reduce its application.

62. **Global Knowledge on Low Methane Agriculture Development.** The low methane and water saving practices applied in this Program will not only support Hunan Province in reducing rice methane emissions, but will also provide important lessons and examples for rice production in China and globally. The proposed PforR will support the Hunan provincial HSFCP under the overall national HSFCP. Since every province in China has a similar program under the HSFCP, the lessons from Hunan can be scaled up and applied in China through those provincial programs. Hunan is a humid region that still relies heavily on continuous flood irrigation, which is similar to the practices in other Southeast Asian countries. Therefore, these lessons are also relevant for other rice producing countries. This Program will also support the establishment of demonstration farms and knowledge exchange for training, showcasing good practices and disseminating information. The Program will develop and issue the provincial strategy and implementation plan to gather lessons learned on low methane rice production, and lay out the action plan for knowledge exchange and dissemination. The innovations and advancement in the MRV system expected to be established by 2025, agricultural water pricing reform, and trading mechanisms will provide lessons to other countries to strengthen their information and institutional systems.

63. **Biodiversity and water security preservation.** The Program will contribute to biodiversity preservation in the Project Province by reducing air and water pollution through: improved fertilizer management (the reduction of chemical fertilizer use, the increases in organic fertilizer and green manure use, and better co-management of water and fertilizer regimes) which will reduce run-offs and emissions, the reduction of straw burning, and more efficient water resource management. Adopting water saving techniques can significantly reduce water use, which can increase downstream water availability and enhance ecological flows for ecosystems. The mitigation measures in this Program will reduce non-point source pollution from rice production as well, which will improve downstream water quality and ensure the water quality requirements to sustain ecosystem services and biodiversity.

64. **Food Security.** The Program will contribute to food security in China, which has a significant implication for the global rice market given that China is the largest importer of rice in the world⁶⁷. The climate adaptation measures will help maintain high yields under the impacts of extreme events of floods and droughts. The climate mitigation measures will consider the interactions among water, fertilizer and straw managements to co-manage these factors to reduce methane emissions while increase yields. The lessons learned are relevant for other rice producing countries to improve food security and contribute to the goals in their NDCs.

3 PROGRAM RESULTS FRAMEWORK AND MONITORING & EVALUATION

3.1 Program Development Objectives

65. **The Program Development Objectives (PDO).** The Development Objective of the Program is “To strengthen methane reduction and climate resilient rice production in Hunan Province”.

66. **The achievement of the PDO will be measured through the following outcome indicators:**
- **PDO#1: Strengthened management system for water-saving and low-methane rice production:** indicated by the regulatory package of documents at the provincial level, consisting of four key documents to enable and mainstream production of water-saving and low methane rice and incentivize adherence of farmers to the new production technologies and practices;
 - **PDO#2: Net GHG emission reduction in demonstration counties:** indicated by the net GHG emission reductions in six demonstration counties, measured by tons of CO₂ equivalent. The net GHG emission reductions are mainly the methane emission reduction through water management, nitrous oxide emission reduction through fertilizer management, and carbon sequestration through straw management and soil fertility improvement. The MRV system will be used to estimate the net GHG emission reductions in the demonstration counties; and
 - **PDO#3: Beneficiaries reached with improved irrigation and drainage services in demonstration counties (of whom women):** measured by the total number of beneficiaries with access to improved irrigation and drainage service reliability as defined in the HSFCP designs in seven demonstration counties.

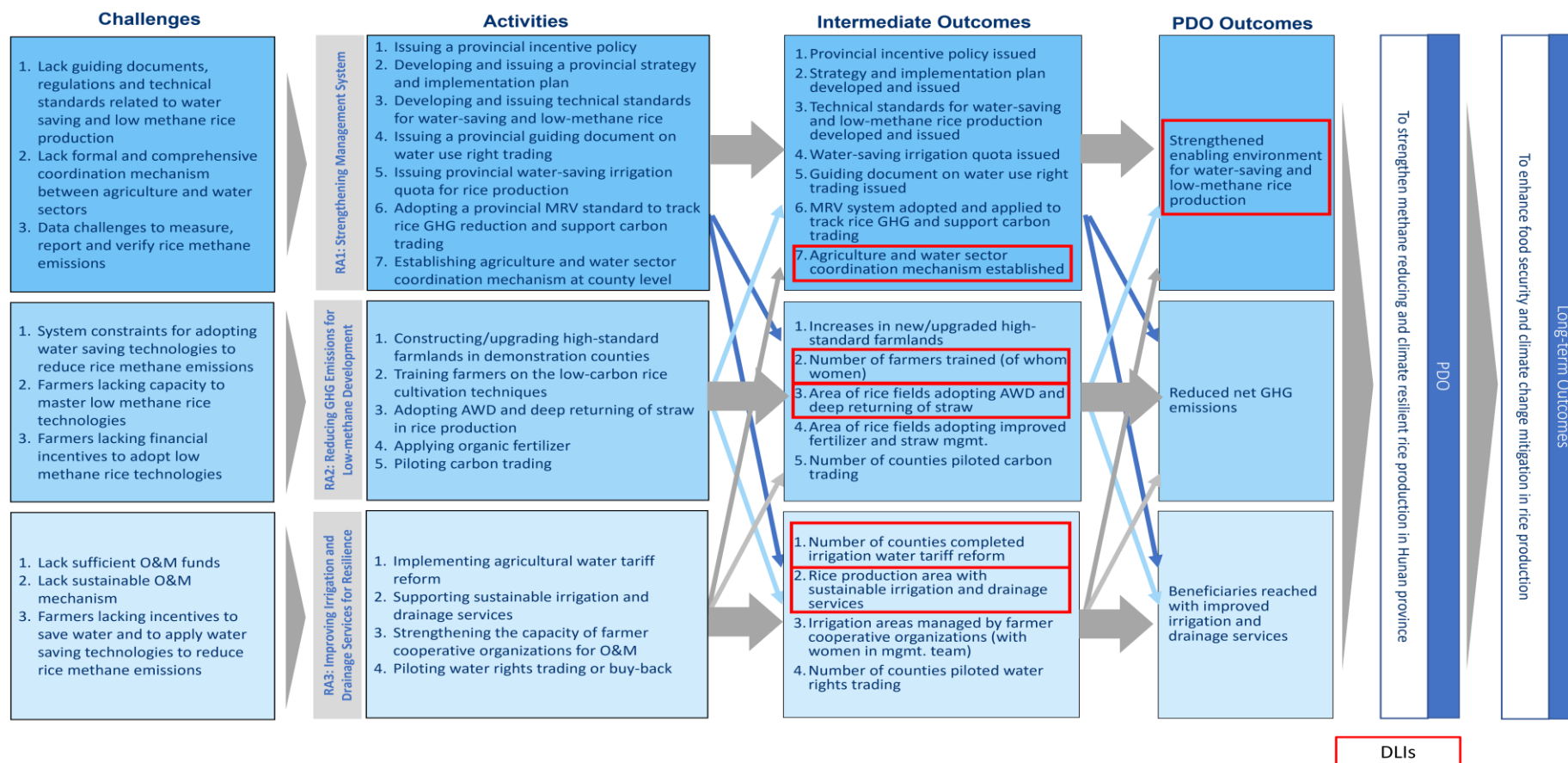
⁶⁷ In 2020, [China](#) imported \$1.72 billion worth of rice, becoming the largest importer of [rice](#) in the world. The Observatory of Economic Complexity (OEC).

3.2 Theory of Change

67. **The Program contributes to the goal of low-methane and climate resilient rice production.** The core challenges to this goal include the system constraints to promote climate mitigation and resilience in rice cultivation, inadequate incentives for farmers to adopt systematically the package solution to achieve multiple-wins objectives, the institutional constraints to guide and coordinate mitigation actions, the information constraints to measure, report and verify GHG emission reductions, and the capacity constraints to adopt and scale up mitigation measures. The Program will support interventions that address these challenges at both provincial and county levels: (a) supporting the development and upgrading of high-standard farmlands at the county level to remove the major system constraints; (b) supporting comprehensive agricultural water pricing reform and piloting carbon trading and water right trading at the county level to create incentives; (c) developing incentive framework, technical standards, and agriculture and water coordination mechanisms to bridge the institutional gaps; (d) developing and implementing MRV system to fill the information gaps; and (e) carrying out comprehensive training and strengthening the extension services to enhance farmers' capacity.

68. **Key assumptions required for the Program's success are that:** (a) the provincial and county governments remains committed to the enabling environment and management reforms under the Program; (b) the institutional arrangements with a strong program leadership and management capacity at provincial and county levels are maintained throughout the program period; and (c) provincial MRV standard will be developed timely under the GARR (Hubei and Hunan) Program as planned to ensure sufficient time for the adoption and application of the MRV system under this Program.

Figure 9: Theory of Change



3.3 Disbursement Linked Indicators and Verification Protocols

69. **The Program's DLIs quantify the parameters and values that need to be achieved to trigger disbursements.** Hunan province and the demonstration counties are responsible for measuring achievement of DLIs within a consistent framework allowing for aggregation and reporting at the Program level. DLIs that were chosen (a) to represent improvements in key aspects of the Government program and the key priorities in each results area; (b) are within the control of the Government; (c) are achievable in the Program period; and (d) are verifiable. They prioritize the use of existing indicators and reporting mechanisms within the Government system where possible, to ensure sustainability.

70. **Verification will be carried out by a third-party verification agency based on data collected by the provincial and county agencies.** At the county level, inspections will be conducted by the county Program Management Office (PMO) on behalf of the county government; at the province level, sample inspections will be conducted by the Provincial PMO on behalf of the Provincial Government. County-level inspections will cover county-level Program activities. An independent verification agency will be contracted by the PPMO. The World Bank will review and approve the terms of reference (TORs) for the verification agency. The Program verification procedures and implementation arrangements are to be detailed in the Program Implementation Plan (PIP).

Table 8: Overview and Rationale for Disbursement Linked Indicators

Disbursement Linked Indicator	Rationale for Selection
<i>Results Area 1: Strengthening management system for sustainable development impacts</i>	
DLI 1: Strengthening management system for water-saving and low-methane rice production	- This DLI aims to address the institutional constraints and create the enabling environment for water-saving and low-methane rice production. The achievement of the DLI 1 will consist of preparation and issuance of four key provincial-level documents which together form the critical document package for enabling, mainstreaming and incentivizing adherence to the new technologies and practices for water-saving and low methane rice production. The preparation, due approval and issuance of the critical documents will be carried out by the provincial authorities. - This DLI will create enabling environment for water saving and low-methane rice production, contributing to climate mitigation. It will also enhance regulations and standards on water saving and drought management, contributing to climate adaptation. - This DLI will contribute to both Pillar 1 Responding to Food Insecurity, and Pillar 3 Strengthening Resilience in the GCPF.
DLI 2: Establishment of agriculture and water sector coordination mechanisms for high-standard farmland construction (number)	- This DLI aims to incentivize effective coordination between agriculture and water sectors in investment planning, implementation and O&M of irrigation and drainage systems. The data sharing mechanism between agriculture and water sectors will also be established. The coordination mechanism will help ensure good performance of the entire irrigation and drainage system for reliable irrigation and drainage services, which is fundamental to climate resilient rice production. - This DLI will support the development of sustainable irrigation and drainage services, which play key roles in enhancing the climate resilience of rice production under floods and droughts. It also lay the foundation to adopt water

Disbursement Linked Indicator	Rationale for Selection
	saving technologies to reduce methane emissions, which contributes to climate mitigation. This DLI will contribute to Pillar 3 Strengthening Resilience in the GCPF.
Results Area 2: Reducing GHG emissions for low-methane development	
DLI 3: Farmers who are trained on the low-methane rice cultivation technologies (of whom women)	- This DLI rewards the adoption-oriented training of rice farmers. It aims to track the number of farmers (of whom women) trained on the low-methane rice cultivation technologies. Systematic training and capacity building are crucial to support farmers to adopt these technologies and achieving the multiple-win results. The low-methane package solutions include the water-straw-fertilizer co-management measures, including water-saving practices, straw deep returning, and organic fertilizer application, as well as other complementary mitigation measures, such as fertilizer deep application, formula fertilizer use, integrated pest management climate-smart rice varieties, and aerobic cultivation techniques. - This DLI will enhance the farmers' capacity to adopt and master the mitigation measures in rice production, contributing to climate mitigation. - This DLI will contribute to Pillar 3 Strengthening Resilience in the GCPF.
DLI 4: Increased rice areas adopting AWD technology and deep returning of rice straw (ha)	- This DLI aims to promote synergized adoption of AWD and deep returning of straws soil practices. It measures the adoption of integrated AWD practice and deep returning of rice straw in the demonstration counties. Methane is the major GHG emitted from rice paddy, and AWD can help reduce substantially the methane emissions. Deep returning of rice straw can coupled with AWD to further reduce methane emissions. The co-management of water and straw can ensure the methane emissions remain low under the condition of straw returning to soil. - This DLI will promote the adoption of key mitigation measures in rice production, contributing to climate mitigation. - This DLI will contribute to Pillar 3 Strengthening Resilience in the GCPF.
Results Area 3: Improving irrigation and drainage services for resilient rice production	
DLI 5: Counties which have completed comprehensive agricultural water pricing reform (Number)	- This DLI aims to motivate water users to save irrigation water and pay for the irrigation services based on the amount of water used, a crucial reform for irrigation O&M cost recovery. Comprehensive agricultural water pricing reform will contribute to improve the sustainability of the irrigation and drainage services, which can enhance the resilience of rice production and create conducive conditions for practicing water saving technologies to reduce methane emissions. - This DLI will support the sustainable irrigation and drainage services, contributing to climate adaptation. It will also generate incentive to save water and adopt AWD, contributing to climate mitigation. - This DLI will contribute to both Pillar 1 Responding to Food Insecurity, and Pillar 3 Strengthening Resilience in the GCPF.
DLI 6: Rice production area with sustainable irrigation and drainage services (1,000 ha)	- This DLI aims to support improving sustainability of irrigation and drainage services to rice producers. Sustainable irrigation and drainage services will be achieved with improved infrastructure, appropriate O&M arrangements, sustainable O&M funding mechanism and cost recovery. - This DLI will ensure sustainable irrigation and drainage services to support the application of AWD, contributing to climate mitigation. The sustainable services will also enhance climate resilience to floods and droughts, contributing to climate adaptation.

Disbursement Linked Indicator	Rationale for Selection
	This DLI will contribute to both Pillar 1 Responding to Food Insecurity, and Pillar 3 Strengthening Resilience in the GCPF.

71. **DLI 1: Strengthening government management system for water-saving and low-methane rice production.** DLI 1 incentivizes the province to develop and issue critical strategies, standards and guiding documents to strengthen the enabling environment for mainstreaming the production of water saving and low methane rice. The regulatory package of documents at the provincial level will consist of four key documents: i) a water-saving and low-methane rice production strategy and implementation plan; ii) technical standards for water-saving and low-methane rice production; iii) provincial water-saving irrigation quota for rice production; and iv) a guiding document on water use right trading. The preparation, due approval and issuance of the critical documents will be carried out by the provincial authorities, supported by the Provincial Program Management Office (PPMO), in close collaboration with the relevant authorities of the participating counties.

- Verification:** The verification will be done at the provincial level. The implementation of the DLI will be carried out by a third-party independent verification agency (IVA), to ensure that: i) the documents have been prepared, duly approved and issued in the required manner; and ii) the documents are of acceptable technical quality. The verification will be carried out on the final issuance of the document based on the criteria in Table 9.

Table 9: Verification Criteria for DLI 1

1. Methane-reducing and water-saving rice production strategy and implementation plan
Technical: - Supports enabling, mainstreaming and incentivizing of low-methane and water-saving rice in Hunan Province - Provides strategic vision and long-term goals to be achieved - Indicates regulatory instruments to achieve the goals and budget availability - Have specific annual targets, implementation pathways, budget allocation, and indicated responsible institutions (these should also be reflected in the implementation plan) - Reflect the Monitoring and Evaluation mechanism, budget, and institutional responsibility - Provides evidence of consultations and contributions with the PforR demonstration counties, as a minimum - Should be based on conditions and specifications of Hunan or those adopted for use in Hunan - Supports voluntary uptake by farmers and provides relevant incentives Procedural: - Has been duly approved by the relevant institution(s) - Issued for public access through websites and in printed form, with one website and one printed dissemination, as minimum
2. Technical standards for low-methane and water-saving rice production
Technical: - Supports enabling, mainstreaming and incentivizing of low-methane and water-saving rice in Hunan Province - Describes the technical parameters of low-methane and water-saving rice production, as well as the technologies and practices to comply with the technical parameters - The procedures related to the enforcement of such standards, institutional framework and responsibilities - Parameters and procedures for monitoring and evaluation of the compliance with the technical standards. Procedural: - Has been duly approved by the relevant institution(s) - Issued for public access through a relevant website and awareness measures taken to announce the availability of the technical standards on the relevant website
3. Water-saving irrigation quota for rice production

Technical: • Supports enabling, mainstreaming and incentivizing of low-methane and water-saving rice in Hunan Province • Describes the technical parameters of water-saving irrigation quota for rice production, as well as the technologies and practices to comply with the technical parameters • The procedures related to the enforcement of such standards, institutional framework and responsibilities • Parameters and procedures for monitoring and evaluation of the compliance with the technical standards. Procedural: • Has been duly approved by the relevant institution(s). • Issued for public access through a relevant website and awareness measures taken to announce the availability of the technical standards on the relevant website
4. Guiding document on water right trading Technical: • Supports enabling, mainstreaming and incentivizing of low-methane and water-saving rice in Hunan Province • Defines the financial instrument (water use right) and its key terms and conditions • Eligibility criteria for buyers and sellers • Trading mechanism and procedures description • Resolutions of issues and disputes • Awareness raising and farmer training mechanism Procedural: • Has been duly approved by the relevant institution(s) • Issued for public access through a relevant website and awareness measures taken to announce the availability of the guiding document on the relevant website.

72. **DLI 2: Establishment of agriculture and water sector coordination mechanisms for high-standard farmland construction.** DLI 2 is measured by the number of coordination mechanisms officially established at county level. These mechanisms will include the coordination in the related investment planning, project design, implementation, and O&M to ensure the synergy between main and on-farm irrigation and drainage systems and services. The agriculture and water sectors are required to share data on the High-Standard Farmland Construction Plan and the related water sector projects.

- **Verification:** Verification will be carried out by the IVA based on: (a) the establishment of official coordination mechanism with agreed operational procedures, verified based on the official announcement by county government; (b) the assignment of dedicated staff with clear responsibility division verified based on the official document by county government or the jointed official document between agriculture and water sectors; (c) the operation of coordination mechanism and regular meetings, verified based on the event records, meeting minutes, and official documents jointed issued by agriculture and water sectors; (d) the coordination between the implementation of HSFCP and Large and Medium Irrigation District Upgrading and Water Saving Improvement Program, verified based on project plans, project implementation reports, annual project summary reports and completion reports; (e) the establishment of data sharing mechanism that the 'One Map' information of large and medium irrigation district upgrading and management and the 'One Map' information of high-standard farmland construction are shared, verified by the jointed official document between agriculture and water sectors.

73. **DLI 3: Farmers who are trained on the low-methane rice cultivation technologies (of whom women).** This DLI supports the targeted training of rice farmers in adopting low-methane package solutions. The low-methane package solutions include the water-straw-fertilizer co-management measures, including water-saving practices, straw deep returning, and organic fertilizer application, as well as other complementary mitigation measures, such as fertilizer deep application, fertilizer use reduction and efficiency improvement, climate-smart rice varieties, and aerobic cultivation techniques.

The training curriculum and training plan are subject to review by the World Bank.

- **Verification:** Data on farmer training will be collected by PPMO and county Program Management Offices (CPMOs). The CPMOs shall establish training ledgers. Surveys and interviews will be carried out to monitor and evaluate the training outcomes. Verification will be carried out by the IVA based on: (a) the review of training ledger, training summary report, training curriculum and materials, and training plan; (b) sequential sampling inspection to randomly sample no less than ten trained farmers in each township, and three percent of professional farmers, farmer cooperatives, farmer associations, family farms, and agro-enterprises, and one percent of smallholder farmers. Within these samples, at least 80 percent of sampled farmers should have received the full training, with over 30 percent of female participants; and (c) field visits to verify the demonstration farmlands and training programs are implemented as planned.

74. **DLI 4: Rice areas adopting AWD technology and deep returning of rice straw to soil (ha).** This DLI measures the areas of high-standard rice farmland adopting AWD technology and deep returning of rice straw, as guided in the technical standards prepared under DLI1. Optimized AWD is promoted under this Program, including AWD at three rice growing stages: i) The early stage of rice growing: around 7 to 10 days of cumulative drying before and after transplanting; ii) The late stage of tillering: around 10 days of cumulative drying; and iii) The yellow ripening to harvesting stage: around 15 days of drying before harvesting. The deep returning of rice straw requires a burying depth of over 15 cm.

- **Verification:** Data on the rice field area adopting AWD technology and deep returning of rice straw will be collected by provincial and county PMOs. The CPMOs will establish the ledgers for each village to record the rice areas adopting AWD and deep returning of rice straw for double-cropping rice, ratooning rice, one-cropping early rice, one-cropping middle rice, and one-cropping late rice. The CPMOs will carry out the preliminary verification on the project implementation reports, machinery application contracts, completion reports, and ledgers, and submit these materials to PPMO for further verification and auditing. Verification will be carried out by the IVA based on: (a) verification of ledgers and other complementary materials, including the project implementation reports, machinery application contracts, and completion reports; (b) random sampling of three villages per each Program counties, including random sampling of five percent of straw returning machinery contracts to verify deep returning of straw and random sampling of one to three percent of rice farmers to verify the adoption of both AWD and deep straw returning technologies (one percent of sampling when the number of rice farmers are more than 500 households, and three percent of sampling when the number of rice farmers are less than 500 households); (c) field soil sampling to verify the depth of straw returning; (d) remote sensing to verify the application of AWD in 10 percent of the areas for the drying at the early stage of rice growing; and (e) where the areas adopting AWD technology and deep returning of rice straw to soil, the smaller area will be used to calculate loan disbursement.

75. **DLI 5: Counties which have completed comprehensive agricultural water pricing reform (Number).** This DLI will measure the results of comprehensive agricultural water pricing reform in demonstration counties, including (a) completing the O&M cost estimation of irrigation and drainage systems, carrying out O&M cost auditing and irrigation water pricing auditing, and establishing rational agricultural water tariff regime (including progressive tariff scheme); (b) establishing irrigation water quota management mechanism and the cap on total agricultural water withdrawal, developing water-saving reward mechanism, and establishing precise budget support/subsidy mechanism; (c) installing water flow measurement facilities; and (d) the promulgation of reformed water tariff.

- **Verification:** Data will be collected by provincial and county PMOs. Verification will be carried out by the IVA based on the related government's official documents, including (a) official approval of the

implementation plan by the higher-level municipal or provincial government; (b) official approval documents by county government for O&M cost auditing, agricultural water tariff regime, water-saving reward mechanism, and precise budget support/subsidy mechanism; (c) official completion reports of the installation of flow measurement facilities; (d) verification of annual progress reports and ledgers; (e) official approval documents and implementation reports by county government on the cap on total agricultural water amount, water quota management, and progressive tariff scheme; and (f) official completion acceptance document on the comprehensive agricultural water pricing reform, approved and verified by the higher-level municipal or provincial government.

76. **DLI 6: Rice production area with sustainable irrigation and drainage services (ha).** This DLI will motivate the counties to improve the long-term sustainability of irrigation and drainage services which are essential for climate-resilient and low-methane rice production. The sustainable irrigation and drainage services consist of (a) well-functioned irrigation and drainage infrastructure; (b) appropriate O&M arrangements with a well-conceived O&M plan and clear O&M responsibility; and (c) a sustainable O&M funding mechanism established to ensure O&M cost recovery.

- **Verification:** Data will be collected by provincial and county PMOs. Verification will be carried out by the IVA based on: (a) the rice cultivation areas that have modernized irrigation and drainage infrastructure system which meet the reliability design criteria for high-standard farmland construction, verified by the official annual completion reports, final acceptance certificates, and the completion data reported and incorporated into the 'One Map' information database of the high-standard farmland construction and management; (b) the newly constructed/rehabilitated irrigation and drainage infrastructure has dedicated entities responsible for the O&M, verified by official and/or signed contract documents showing WUAs, farmer cooperation organizations, and village collectives as the main O&M entities; and (c) the O&M cost should be reasonably covered with a combined source of collected irrigation water tariff, precise financial budget support and other sources, verified by the actual financial reports recording the water tariff collection, budget support and other sources which can cover at least 80 percent of the O&M costs. The verification of (b) and (c) will be based on random sampling, which will sample one third of the large and medium irrigation districts, as well as two percent of the O&M entities.

4 PROGRAM EXPENDITURE FRAMEWORK

77. **Total Program financing over the period from FY 2024 to 2028 is expected to be US\$1,243 million.** This estimation is based on the initial expenditure framework assessment (EFA). The expenditure framework in the six demonstration counties in Hunan Province presents an adequate basis for the PforR Program. RA 2 and RA 3 involve intensive public investment, while RA 1 focuses on institutional strengthening and innovation with relatively small public expenditure. Thus, the EFA mainly focuses on the budgets and expenditures related to the activities under RA2 and RA3 that are supported under the budget lines of both the agriculture and water sectors. Based on the budget data from 2019-2021, the EFA shows that the six demonstration counties spent a total of US\$ 790.5 million equivalent for Program-related activities. It is forecasted that the Program financing from the Government will reach US\$988 million from FY 2024 to 2028.

Table 10: Program Financing by Result Areas (FY 2024-28)

Result Areas	2019-2022 actual (US million)	FY2024-2028 estimated (US million)	
	Hunan	Hunan	Share (%)

RA1	1.6	2.0	0.2
RA2	469.4	586.7	59.4
RA3	319.5	399.3	40.4
Total	790.5	988.1	100.0

78. **Program Expenditure Boundary.** Hunan has an integrated financial management system to allocate budgets and track public expenditures. According to the budget classification, there are some major budget lines recording the budget expenditures for the Government program: “Agriculture and Rural Affairs” (code 21301) managed by the PDARA, including “Agricultural Production Development” (code 2130122) and “Farmland construction” (code 2130153); and “Water Conservancy Affairs” (code 21303) managed by the PDWR, including “Water Resource Conservation Management and Protection” (code 2130311) and “Farmland water conservancy” (code 2130316).

Table 11: Program Expenditure Boundary in 2019-2021 (US\$ million)

Code	Budget Line	Government Program	PforR Program	
		Six counties of Hunan	Result Area	Six counties of Hunan
21301	Agriculture and Rural Affairs	926.4		
2130101	Administrative Operation			
2130102	General Administrative Services			
2130103	Agency Service			
2130104	Business Operation			
2130105	Farm Reclamation Operation			
2130106	Technology Transformation and Promotion Services		RA2	13.0
2130108	Pest Control		RA2	14.9
2130109	Agricultural Product Quality and Safety		RA2	1.9
2130110	Law Enforcement Supervision			
2130111	Statistical Monitoring and Information Services		RA1	0.0
2130112	Industry Business Management		RA1	0.0
2130114	Foreign Exchange and Cooperation			
2130119	Disaster Prevention and Relief			
2130120	Stable Farmers Income Subsidy			
2130121	Agricultural Structural Adjustment Subsidies		RA2	14.8

Code	Budget Line	Government Program	PforR Program	
		Six counties of Hunan	Result Area	Six counties of Hunan
2130122	Agricultural Production Development		RA2	276.0
2130124	Rural Cooperative Economy		RA3	8.9
2130125	Agricultural Processing and Promotion			
2130126	Rural Social Undertaking			
2130135	Protection, Restoration and Utilization Of Agricultural Resources		RA2	34.0
2130142	Rural Road Construction			
2130148	Refined Oil Pricing Reform Subsidy to Fishery			
2130152	Subsidy For College Graduates to Work at The Grassroots Level			
2130153	Farmland Construction		RA2	114.9
2130199	Other Agricultural and Rural Expenditures			
21303	Water Conservancy	542.6		
2130301	Administrative Operation			
2130302	General Administrative Services			
2130303	Agency Service			
2130304	Business Management of Water Conservancy Industry		RA1	1.5
2130305	Water Conservancy Project Construction		RA3	207.5
2130306	Operation and Maintenance of Hydraulic Engineering		RA3	46.3
2130307	Yangtze River And Yellow River Basin Management			
2130308	Preliminary Work of Water Conservancy			
2130309	Water Conservancy Law Enforcement Supervision			
2130310	Soil And Water Conservation			
2130311	Water Resources Conservation Management and Protection		RA3	1.3
2130312	Water Quality Monitoring			
2130313	Hydrologic Survey			
2130314	Flood Control			
2130315	Drought Resistance			
2130316	Farmland Water Conservancy		RA3	55.4
2130317	Water Conservancy Technology Popularization			

Code	Budget Line	Government Program	PforR Program	
		Six counties of Hunan	Result Area	Six counties of Hunan
2130318	International River Governance and Management			
2130319	Comprehensive Improvement of River, Lake and Reservoir Water Systems			
2130321	Support the Late Migration of Large and Medium-Sized Reservoirs			
2130322	Water Conservancy Safety Supervision			
2130333	Information Management			
2130334	Land Expropriation and Immigration for Water Conservancy Construction			
2130335	Drinking Water for Rural People and Animals			
2130336	Construction of the South-To-North Water Diversion Project			
2130337	Management of South-To-North Water Diversion Project			
2130399	Other Water Expenditure			
Total Amount		1469.1		790.5
As percent of government program (%)				53.8

79. **Program Funding Source:** The county-level governments and the counties rely heavily on the transfers from the higher-level governments (HLG) or the central and provincial governments for financing of the Program activities. There are three mechanisms used by the HLGs to transfer funds to the county governments to support the Paddy Rice PforR activities, namely, “Transfer for central-local shared functions on agriculture, forestry and water affairs,” “Incentive funds of main grain (oil) producing counties,” and “Ear-marked transfers for agricultural, forestry and water affairs,” of which the “Ear-marked transfer for agricultural, forestry and water affairs” is an earmarked transfer, while the other two are general transfers. The earmarked transfers provide strong incentives for counties to implement the Program activities, while general transfers help to fill in the financing gaps as needed. From 2019 to 2022, the three transfers allocated by HLGs to the program counties amounted to a US\$ 1,320.7 million equivalent. Given that the bulk of the Paddy Rice PforR expenditures would be financed by HLG transfers, it can be concluded that the program financing from the Government is adequate and largely predictable.

Table 12: Program Funding Sources during 2019-2022 (US\$ million)

Transfers	six project counties of Hunan				
	2019	2020	2021	2022	Total
General Transfers					
Incentive Funds for Main Grain (Oil) Producing Counties	23.5	30.9	30.5	37.4	122.2

Transfers for Central-Local Common Functions on Agriculture, Forestry and Water Affairs	194.8	100.3	73.0	88.1	456.1
Ear-Marked Transfers					
Ear-Marked Transfers for Agricultural, Forestry and Water Affairs	140.3	192.2	202.2	207.8	742.4
Total	358.6	323.3	305.7	333.2	1320.7
Share of Earmarked Transfers (%)	39.1	59.4	66.2		

80. **Expenditure Performance and Financial Sustainability.** The assessment found that the ear-marked transfers related to the Program activities under RA2 and RA3 are adequate, and that the expenditure performance evaluation system is in place. A series of documents on earmarked fund management have been issued by the MOF, and the PDARA and PDWR in Hunan that stipulate that the transferred funds will only be used for the specified activities. The fund allocations are factor-based or project-based, and subject to performance evaluation. The performance evaluation results are taken as an important factor for fund allocation. Therefore, there are strong incentives for the Program counties to achieve the desired objectives of promoting water-saving and low-methane rice production and to ensure value for financing. The recent General Public Budget Revenue (GPBR) in the Hunan Province has been relatively stable, despite the negative impacts of COVID-19 pandemic. The total expenditure of this Program only accounts for about 0.5 percent of the GPBR in Hunan. Thus, the Program funding appears sustainable.

81. In particular, noticeable amounts of ear-marked funds have been arranged in recent years to support the agricultural water pricing reform, which involves a number of activities closely related to the objectives of the Paddy Rice Program. These activities include providing water-savings awards and water price subsidies as well as constructing and maintaining water metering facilities in irrigation areas. Specifically, from 2019 to 2022, a US\$ 2.3 million equivalent from the Central and Provincial Water Conservancy Development Fund was allocated to six demonstration project counties to support comprehensive agricultural water pricing reforms; in 2021, a US\$ 0.2 million equivalent from the provincial budget funds was allocated to the pilot county of Hanshou where the agricultural water tariff reforms were taking place, to support the construction and maintenance of water metering facilities. In general, both the central government and Hunan Provincial government have been enhancing financial support for water-saving paddy production. In 2019, the Hunan PDRC, PDOF, PDWC and PDARA jointly issued the Management Method of the Fund for Awards and Subsidies of the Agricultural Water Price Comprehensive Reform in Hunan, which stipulates that the DWC will organize and implement the performance evaluation for the Fund and the PDOF will review the performance evaluation results and allocate the Fund accordingly.

Table 13: Earmarked Funds Supporting RA2 and RA3 Activities in Hunan (2019-2022), US\$ million

Ear-marked Transfer Program	six program counties of Hunan				
	Province	%	Central	%	Total
Finance Department	187.7	27.2	502.2	72.8	689.9
Agricultural Production Development Fund	17.5	5.2	317.2	94.8	334.7

Farmland Construction Subsidy	58.7	31.6	126.9	68.4	185.6
Water Conservancy Development Fund	94.8	64.7	51.6	35.3	146.4
High Standard Farmland Management and Protection Fund	16.8	100.0	0.0	0.0	16.8
Agricultural Resources and Ecological Environment Protection Fund	0.0	0.0	6.4	100.0	6.4
Development and Reform Commission	0.2	0.1	151.5	99.9	151.7
Funds for Agricultural Production Development Project	0.0	0.0	89.0	100.0	89.0
Funds for Ecological Protection and Restoration Projects in Key Areas	0.0	0.0	19.9	100.0	19.9
Funds for Large-scale Irrigation Area Construction and Modernization Projects	0.0	0.0	19.0	100.0	19.0
Funds for Water Security Projects	0.0	0.0	15.3	100.0	15.3
Funds for Agricultural Sustainable Development Projects	0.0	0.0	8.2	100.0	8.2
Funds for Comprehensive Agricultural Water Pricing Reform in Selected Counties	0.2	100.0	0.0	0.0	0.2
Total	187.9	22.3	653.7	77.7	841.6

Table 14: Financial Situation in terms of General Public Budget in Hunan

Description	Hunan		
	2019	2020	2021
General Public Budget Revenue (GPBR), US\$ billion	43	43	46
Transfer From Central Government (TFCG), US\$ billion	53	60	58
GDP, US\$ billion	570	593	658
Debt Balance (DB), US\$ billion	145	169	194
Debt Repayment Amount (DRA), US\$ billion	21	13	20
Debt-to-GPBR Ratio (=DB/GPBR+TCG), %	152	164	186
Debt-to-GDP Ratio (=DB/GDP), %	26	28	30
Debt Repayment Ratio (=DRA/GPBR+TCG), %	22	13	19

5 STRATEGIC RELEVANCE AND TECHNICAL SOUNDNESS

5.1 Strategic Relevance

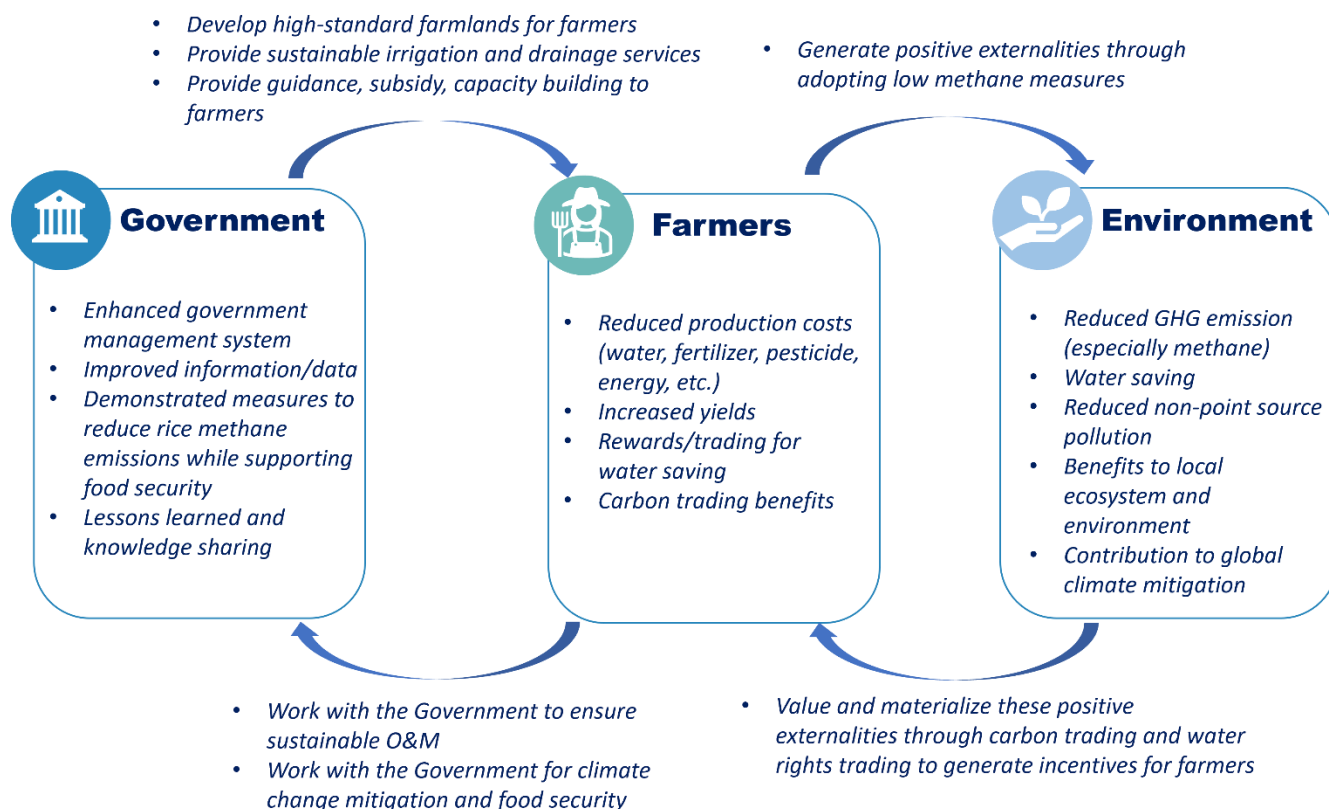
82. **The Government, farmers and the environment will benefit from this Program to achieve the win-win outcomes of climate change mitigation and resilience in the rice sector.**

- **Government:** Reducing rice methane emissions is considered as the first task for emission reduction in the agricultural sector in China and Hunan Province. However, these priorities have

not been translated into specific climate mitigation actions and measures. The Program will demonstrate the effective climate mitigation measures of reducing rice methane emissions, support the Government to strengthen its management system to scale up these measures, bridge the data gaps in tracking rice methane emissions, and explore possible incentive mechanisms. The Program will support the Government to develop high-standard farmlands for farmers, to provide sustainable irrigation and drainage services for farmers, as well as to enhance the farmers' capacity. This Program will provide the Government replicable lessons to reduce rice methane emissions while supporting food security. The Program is expected to generate knowledge on low methane rice production that will benefit other provinces in China, as well as other rice-producing nations.

- **Farmers:** Farmers will benefit from the reduction of production costs in water, fertilizer, pesticide and pumping energy, as well as the increasing of their incomes through increased yield and rewards/payment for water saving. Carbon trading can bring in additional benefits. Farmers will benefit from the high-standard farmlands and improved irrigation and drainage services, and will work with the Government to ensure the sustainability O&M. The Cost-Benefit Analysis (Table 3.9 in Annex 3) showed that rice farmers could gain incremental net income at around CNY 1,935/ha (US\$ 280/ha) without carbon trading, and CNY 2,608/ha (US\$ 380/ha) with carbon trading benefits (with a low carbon price).
- **The environment:** The Program will generate positive externalities of reducing methane emissions, water use, and non-point source pollution, which will benefit local ecosystems and environment, as well as contribute to global climate change mitigation. This Program will explore the mechanisms of carbon trading and water rights trading to value and materialize these positive externalities, which will in turn generate incentives for farmers to adopt low methane and water saving measures.

Figure 10: Program Benefits for the Government, Farmers and the Environment



83. **The proposed PforR Program will address the priorities in Hunan to achieve the win-win outcomes of climate mitigation and resilience in the rice sector, and generate lessons for China and beyond.** Rapid reduction of methane emissions is regarded as the single most effective strategy to keep the Paris Agreement goal of limiting global warming to 1.5°C. Reducing rice methane emission is the key path to reduce methane while yielding co-benefits of improving agricultural productivity, which is also considered as the first task for emission reduction in agricultural sector in China and Hunan Province as indicated in a number of strategic documents. However, these priorities have not been translated into specific mitigation actions and measures. This Program will address these priorities and provide replicable lessons to reduce rice methane emissions while supporting food security through improving productivity and resilience in the sector. The Program is anchored in the ambitious and solid Government's program of Hunan HSFCP. The Program will leverage the opportunities of Hunan HSFCP to create conducive conditions for adopting mitigation measures, while bridge the gaps to improve the enabling environment, scale up mitigation measures to reduce rice GHG emissions, and improve irrigation and drainage services to enhance resilience. This Program will address both mitigation and adaptation aspects of rice production and will contribute to the long-term outcomes of climate mitigation and food security. The Program is expected to enrich the international knowledge and experiences of low-methane rice production benefitting other rice-producing nations.

84. **The PforR Program will leverage the dedicated government program of Hunan province, high-standard farmland construction plan (2021-2030) (HSFCP) to scale up mitigation measures and enhance resilience.** The proposed PforR will be implemented at both provincial and demonstration county levels. The PforR Program will leverage the opportunities in Hunan HSFCP to remove the system constraints for adopting mitigation measures and enhancing resilience, by building more reliable and flexible irrigation and drainage systems, enhancing soil quality and fertility, and improving associated high-standard

farmland facilities. The Program will bridge the gaps to incorporate the mitigation concepts and measures into Hunan HSFCP, and scale up these measures with comprehensive training programs. Provincial strategy, regulations, guidelines and standards will be developed and issued to guide the implementation of mitigation measures at county level. The coordination mechanism between agriculture and water sector will be established. The Program will use the provincial MRV system to track rice GHG emissions, including methane. Agricultural water tariff reform will be implemented to create incentives for saving water and to support sustainable O&M. Carbon trading and water trading mechanisms will be explored and piloted to further generate incentives.

5.2 Technical Assessment by Results Area

85. **The technical assessment has established a sound PforR boundary.** The Program is embedded within the Government's program of Hunan HSFCP (2021-2030). Three distinct and complementary sets of activities will be included in the Program design that are integral to the Government program: strengthening management system for sustainable development impacts (Results Area 1); reducing GHG emissions for low-methane development (Results Area 2); and improving irrigation and drainage services for resilient rice production (Results Area 3). The Program boundary will include physical and non-physical activities in the seven demonstration counties (distributed in five municipalities) under RAs 2 and 3, as well as non-physical or soft activities under RA1 which are mostly at the provincial level. The agreed Program boundary after environmental and social risk screening (excluding the high-risk activities) is shown in Table 6 above. The timeline for the PforR is from Year 2023 to 2028, with 2021 being the baseline year. This is well aligned with the timeline of Hunan HSFCP from Year 2021 to 2030 with clear targets established.

Results Area 1: Strengthening management system for sustainable development impacts

86. **Results Area 1 will strengthen government management system for promoting rice mitigation measures.** RA1 will focus on strengthening the management system for low-methane and climate-resilient rice production. The management system includes regulations, strategic plans, standards and other guiding documents as well as management organizations. Preliminary assessment of the government management system in Hunan province shows that there are general policies, regulations and strategic plans for agriculture green development, most stringent water resources management and agricultural water conservation. However, there are no specific strategy and implementation plan for water-saving and low-methane production in Hunan. The related technical standards need to be updated. Agriculture and water sectors have some initial coordination mechanisms, but these mechanisms need to be improved and formalized. In the effort of filling information gaps, the Program also gives priority to develop a provincial MRV standard and implement it in the selected counties. As GARR (Hubei and Hunan) Program plans to develop the MRV methodology for rice paddy in Hunan Province, this Program will focus on the implementation of this MRV in selected counties to support carbon trading.

87. **The initial assessment shows that Hunan has a fairly good institutional system at provincial and county levels for low-methane and water-saving rice production.** The assessment in Table 15 shows that both national and provincial level had launched general policies to guide green and low-methane development. However, specific strategies and regulatory frameworks were not available in Hunan to guide water-saving and low-methane rice production. Therefore, the Program will support the development and issuance of a provincial incentive framework to create incentives for adopting mitigation measures, a provincial strategy and implementation plan to promote and scale up mitigation

measure, and a provincial guiding document on water use right trading. The assessment also indicated that there is no technical standard for low methane and water saving rice production. Thus, the Program will support the development and issuance of these technical standards on the co-management of water-straw-fertilizer, which can guide the county to implement the recommended mitigation measures. Both agriculture sector and water sector at provincial and county levels expressed their needs and willingness to coordinate and collaborate in the areas of high-standard farmland development and agricultural water conservation. There is no concrete and operational cooperation and coordination mechanism. Data sharing between two sectors is still challenging. The Program will support the establishment of official coordination mechanisms between agriculture and water sectors.

Table 15: Initial Assessment of the Strategic and Regulatory Framework, Standards, and Agriculture and Water Coordination Mechanisms

Status	Gaps	Recommendations
Strategic and Regulatory Framework		
National level 1. The State Council's Guiding Opinions on Accelerating the Establishment and Improvement of a Green and Low-methane Circular Development Economic System (GF [2021] No. 4) 2. Opinions of the Central Committee and the State Council on Innovating System and Mechanism to Promote Agricultural Green Development (September 2017) 3. Regulation on Farmland and Water Conservancy (Order No. 669 of the State Council of the People's Republic of China) 4. Yangtze River Protection Law of the People's Republic of China (December 26, 2020) 5. No. 1 central documents over the years Provincial Level 1. Hunan's Implementation Plan for Carbon Peaking (XZF [2022] No. 19) 2. Administrative Measures of Hunan Province on Water Conservation (Order No. 293 of the People's Government of Hunan Province) 3. Implementation Plan for Promoting the Comprehensive Reform of Agricultural Water Price in Hunan Province in an Orderly Manner (2022) 4. The General Office of the People's Government of Hunan Province: Measures for the Assessing the Performance of the Most Strict Water	National level National regulatory instruments are issued on such areas as agricultural water conservation, low methane and ecological circular agriculture, manure resource utilization, and crop straw utilization, treatment of agricultural plastic film pollution, planning and construction of farmland water conservancy projects, and management and mire clarified protection responsibilities. Provincial Level Hunan has not prepared adequate strategy, regulations and operational plans related to water conservation and methane reduction in paddy fields.	Provincial level: It is recommended to introduce strategic and regulatory framework for water-saving and low-methane development of rice fields as per the regulatory instrument preparation schedule in Hunan; The establishment of provincial carbon trading management measures or implementation rules shall be prepared as per carbon trading pilots; The guiding opinions on water rights trading in Hunan Province shall be issued. County Level The regulatory and management measures at the county level are more refined as per the local conditions. For example, whether the counties can issue detailed rules for the implementing water rights trading in accordance with the provincial guides on water rights trading.

Status	Gaps	Recommendations
Resources Management System in Hunan (XZBF [2013] No. 62)		
Technical Standards and Guidelines		
There are no technical guidelines or standards for water conservation and methane reduction in paddy fields at both national level and Hunan Provincial level (Jiangsu and Heilongjiang have issued technical standards for rice water-saving irrigation).	There is no standard for water saving and methane reduction for paddy fields at the national level, in the water resources sector and locally in Hunan. The gaps need to be filled.	Provincial Level: 1. Technical Specifications for Water-saving and Low-carbon Development of Paddy Rice in Hunan Province to promote good practices shall be prepared and issued by Department of Agriculture and Rural Affairs. The other option is that Hunan can authorize national academic societies (E.g. Chinese Academy of Agricultural Sciences) to prepare the recommended technical standards, which can be further proposed for national adoption for larger impact. 2. It is suggested that Department of Water Resources shall formulate and issue Technical Standard for Rice Water-saving Irrigation in Hunan Province; 3. The MRV for carbon sequestration and emission reduction in rice production shall be developed and issued.
Capacity Building for Extension Service Providers		
· Law of the People's Republic of China on Agricultural Engineering Extension (2012); · Measures of Hunan Province for the Implementing the Law of Agricultural Technology Engineering Extension (2012); · At present, the extension network is built with the national agricultural technology extension center, and extension stations in provinces, cities, counties and towns, to promote and extend good practices and technologies.	It is the government and public institutions who are responsible for the extension; the market mechanism and market-oriented technology extension service institutions or organizations shall also be developed and involved in.	County Level: Hunan proposes to establish county (grassroots) agricultural machinery service centers, which is the market driven mechanism to strengthen the service and institutional capabilities and promote technologies for rice water conservation and methane reduction. In this way, the service mechanism driven by both the government and the market shall be built.
Agriculture and Water Coordination Mechanism		
1. Department of Water Resources and Department of Agriculture and Rural Affairs together issued Guiding Opinions on Strengthening the Cooperation between the Reconstruction of Large and Medium-sized Irrigation Areas and the Construction of High-standard	Both water resources and agriculture sectors are willing to collaborate in such areas as high-standard farmland development and agricultural water conservation; but this is no concrete and operational cooperation and coordination mechanism is built.	County Level: In the Project counties, a coordination mechanism can be built (such as joint meeting system) for agriculture and water resources to jointly promote the

Status	Gaps	Recommendations
Farmland (2022); 2. Department of Water Resources issued the Opinions on Strengthening the Construction and Management of Large and Medium-sized Irrigation Districts (2022)		construction of high standard rice fields on a voluntary basis.

88. **An MRV system is crucial to measure and verify the GHG emission reduction from rice paddy and to support the carbon trading pilot.** The government is facing information challenge to better measure, report and verify the GHG emissions. Global Methane Pledge recognized that the improvements to the transparency, accuracy, completeness, comparability, and consistency of methane emissions data assessed and validated can promote more ambitious and credible actions. China also highlighted at COP27 that a lack of reliable baseline data on methane emissions hampered the implementation of the methane reduction plan. MRV system is crucial to track GHG emission reduction and to support carbon trading. Built upon the MRV methodology developed in GARR (Hubei and Hunan), this Program will measure, report and verify rice GHG emissions in selected counties, which will also support the carbon trading pilots in these counties. A monitoring network will be established with both remote sensing and in-situ measurements. Remote sensing technology will be explored to measure methane emission at large scale, as well as other factors impacting rice GHG emissions, such as rice production areas, rotation practices, and rice water practices. In-situ ground monitoring will be established to directly measure rice GHG emissions, as well as the impacting factors of climate, soil types, fertilizer and straw management practices, and other agronomic practices.

Results Area 2: Reducing GHG emissions for low-methane development

89. **Results Area 2 will leverage the Government's program of Hunan HSFCP to scale up rice mitigation measures.** RA2 supports the government's endeavor in promoting low-methane rice production to reduce methane emission from rice paddy. The Program is anchored in the Government's program of Hunan HSFCP. Over the past decade in the 2010s, Hunan has seen an increasing investment in high-standard farmlands, which lays a sound foundation for adopting mitigation practices. Rice methane emission is expected to be effectively reduced through the adoption of water saving techniques, such as AWD. Fertilizer and straw management will further reduce rice GHG emissions. However, the counties are falling short in systematic adoption of those technologies as an integrated solution package, through co-management of water, fertilizer and straw residue. For that reason, the Program will give priority to promote and scale up the integrated mitigation solution package through comprehensive training and capacity building. In addition, it is recommended that trading of carbon emission reduction achieved under the Program should be piloted in selected counties to generate financial revenue for motivating farmers to adopt the low-methane and water-saving cultivation. Although the China Certified Emission Reduction (CCER) system⁶⁸, the voluntary GHG emission reduction trading platform, was suspended to accept new application since 2017, the government and other entities still explore opportunities for rice carbon trading.⁶⁹

⁶⁸ CCER scheme focuses on the voluntary GHG emission reduction transactions, such as the GHG emission reductions from renewable energy, forestry carbon sink, methane reduction and utilization. CCER used to apply CDM methodology ([link](#)) to quantitatively verify and register the credits of rice methane reduction through better water management.

⁶⁹ In July 2022, one case of carbon trading on rice methane emission reduction was completed in Fujian Province. It traded the methane emission reduction from rice paddies due to the adoption of AWD. ([link](#))

90. **The Program will support specific activities in Hunan HSFCP, which will lay solid and conducive conditions for adopting mitigation measures.** The Program will remove the system constraints for adopting mitigation measures by supporting the selected key activities in Hunan HSFCP, including the construction and rehabilitation of irrigation and drainage systems, the improvement of small water storages, land levelling, the improvement of soil quality and fertility, as well as the development of high-standard farmland associated facilities, such as on-farm access roads and on-farm windbreak shelter forests and grasses. These interventions will provide flexible irrigation and drainage services with reliable water supply, and well-leveled farmlands with the suitable size for irrigation, drainage and machinery application, which will create the basic foundation for adopting mitigation measures.

91. **Co-management of water, straw and fertilizer provides an integrated package solution to effectively reduce rice methane emissions, with the consideration of the synergies and interactions among various factors.** Unlike methane emissions, nitrous oxide (N₂O) emission is generally low under anaerobic conditions. Better fertilizer management⁷⁰ can reduce GHG emissions, especially the emission of nitrous oxide. As the application of AWD may slightly increase nitrous oxide emissions,⁷¹ co-management of water and fertilizer application can reduce methane emissions, while ensuring that the nitrous oxide emissions remain low.⁷² These benefits extend to the reduction of non-point source pollution from rice cultivation. Returning straws to soil can improve soil fertility and increase soil carbon sink. However, the decomposition of fresh crop straws under anaerobic soil conditions can also increase methane emissions. Combining AWD with proper straw returning enables the aerobic decomposition of straw residues, which will significantly lower methane emissions.^{73, 74} Thus, the co-management of water and straw is also critical. In addition, off-farm straw utilization, optimal rice varietal selection, improved machinery management, can further contribute to the reduction of rice GHG emissions.⁷⁵ Post-harvest systems, including processing, waste disposal, and transportation, only account for a small portion of rice GHG emissions through the rice value chains in China.⁷⁶ Thus, the proposed Program-for-Results (PforR)

⁷⁰ Some fertilizer application strategies, such as urea deep placement, can slow the releasing of N-fertilizer and the related nitrous oxide emission. Reducing the application of chemical fertilizer and enhancing fertilizer utilization efficiency can also reduce fertilizer use and the related nitrous oxide emission.

⁷¹ Unlike methane emissions, nitrous oxide emission is generally low under waterlogged conditions, because nitrification and denitrification (both of which can produce nitrous oxide) of mineral N is limited. The drying of paddy fields can significantly reduce methane emissions, but it may also increase nitrous oxide emissions. It was estimated that, under AWD, 15–20 percent of the benefit gained by decreasing methane emission is offset by the increase in nitrous oxide emissions. However, the net GWP is still significantly lower under AWD than in continuously flooded fields due to the substantial reduction of methane emissions under AWD. Richards M, Sander BO. 2014. Alternate wetting and drying in irrigated rice. Climate-Smart Agriculture Practice Brief. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). ([link](#)); Yu Jiang, Daniela Carrijo, Shan Huang, et al. (2019) Water management to mitigate the global warming potential of rice systems: A global meta-analysis, Field Crops Research, Volume 234, Pages 47-54, ISSN 0378-4290 ([link](#))

⁷² Balaine, N., Carrijo, D.R., Adviento-Borbe, M.A. and Linquist, B. (2019), Greenhouse Gases from Irrigated Rice Systems under Varying Severity of Alternate-Wetting and Drying Irrigation. Soil Science Society of America Journal., 83: 1533-1541. ([link](#))

⁷³ Hang X. et al., 2014. Differences in rice yield and CH₄ and N₂O emissions among mechanical planting methods with straw incorporation in Jianghuai area, China. Soil and Tillage Research 144, 205-210

⁷⁴ Linquist B. A. et al., 2015. Reducing greenhouse gas emissions, water use, and grain arsenic levels in rice systems. Global Change Biology. 21, 407-417. ([link](#))

⁷⁵ In the major rice production regions of south China, methane emissions account for around 65-75 percent of the total rice GHG emissions. Fertilizer application accounts for 5-10 percent of total emissions, straw burning contributes to 5-20 percent of emissions, and agricultural machinery is responsible for 5-10 percent of emissions. Thus, besides the water saving technologies for methane emission reduction, other agricultural solutions are also critical to further reduce rice GHG emission. Zhang, D., Shen, J., Zhang, F. et al. (2017) Carbon footprint of grain production in China. Scientific Reports 7, 4126. ([link](#)). The results were based on the life cycle analysis of carbon emissions per unit yield (kgce/kg).

⁷⁶ Huayang Zhen, Xu Feng, Muhammad Ahmed Waqas, et al. (2023), Solutions to neutralize greenhouse gas emissions of the rice value chain — A case study in China, Sustainable Production and Consumption, Volume 35, 2023, Pages 444-452, ISSN 2352-5509 ([link](#))

mainly focuses on the reduction of rice methane emissions during rice production.

92. **AWD technology is among the most effective practices to reduce methane emission from rice production.** Methane in rice paddy is mainly produced by microbial decomposition of organic matter in flooded and anaerobic environments. When rice paddy fields are drained or alternately dried, there are more oxygen in the soil, which is not conducive to the production of methane. Most of the formed methane will be converted into carbon dioxide by microorganisms, which has a significant reduction in global warming potential. A large number of scientific studies and field monitoring have proved that water control and shortening the number of days of flooding in rice growing season can reduce methane emissions by 30 to 70 percent.⁷⁷ A global meta-analysis revealed that mild drying did not reduce the rice yields. Safe-AWD with mild drying provides benefits of allowing drying periods to reduce methane emissions without sacrificing yields.⁷⁸ China has been promoted water saving techniques, including AWD, for over four decades. Among these techniques, the shallow-wet-dry irrigation technique (also called as shallow water depth with wetting and drying), is the most widely used technique. The shallow-wet-dry irrigation technique consists of two drying periods—one at the late stage of tillering, and one at yellow ripening stage. Intermittent irrigation technique, one kind of AWD techniques, is also frequently used in south, north and northeast China. Semi-dry technique (also called as controlled irrigation) is used in some relatively water scarce regions, which only keeps a water layer at the stages of turning greening and early tillering and keeps the dry field during other growing stages. With the long-term promotion of rice water saving practices, rice farmers in China usually have a good understanding of the importance of drying, especially the drying at the late stage of tillering, which can help rice increase more profuse early tillering and suppress unproductive late tillering to enhance yields, develop sturdy stems and well-developed roots to be resistant to lodging, and enhance the resistance to rice diseases. Therefore, many rice farmers in China practice mid-season drainage at the late stage of tillering if irrigation and drainage conditions allow. Farmer consultation and stakeholder engagement under this Program showed the similar situation in Hunan that majority of farmers practice drying at the yellow ripening to harvesting stage, while some farmers practice drying at the late stage of tillering if conditions allow.

93. **Straw returning to rice field can improve soil fertility, increase soil carbon sequestration and reduce chemical fertilizer use.** Fresh plants such as crop stalks and green manure contain a lot of mineral nutrients, and they are also the main food source for soil organisms. Soil is a living body, and soil health and productivity need to be maintained and improved by organisms such as soil animals and microorganisms. Therefore, returning crop straw and green manure to farmlands does not only benefit high and stable crop yields, but also strengthens the soil health and fertility. In addition, these organic substances can also significantly increase the content of soil organic carbon, and promote soil carbon sequestration to mitigate climate change.⁷⁹ The effect of increasing the sink of straw returning to the field can last for 20 to 30 years, and the effect of increasing the sink of organic fertilizer application can last for 40 to 50 years.⁸⁰ Moreover, the input of these organic materials can significantly reduce the application of chemical fertilizers, for example, green manure planting can reduce by 30 to 40 percent the amount of fertilizer applied by conventional crop, and the effect of fertilizer saving and emission reduction is remarkable. In the Intergovernmental Panel on Climate Change (IPCC) guidelines and International

⁷⁷ Jiang Y. et al., 2019. Water management to mitigate the global warming potential of rice systems: A global meta-analysis. *Field Crops Research* ([link](#)).

⁷⁸ Jiang Y. et al., 2019. Water management to mitigate the global warming potential of rice systems: A global meta-analysis. *Field Crops Research* ([link](#)).

⁷⁹ Lal R., 2004. Soil carbon sequestration impacts on global climate change and food security. *Science*, 304(11): 1623-1627. ([link](#))

⁸⁰ Rui W. et al., 2010. Effect size and duration of recommended management practices on carbon sequestration in paddy field in Yangtze Delta Plain of China: A meta-analysis. *Ecosystems and Environment* 135: 199–20. ([link](#))

Organization for Standardization (ISO) emission reduction standards, these measures are recommended as important measures to improve farmland climate resilience, reduce emissions, and enhance carbon sequestrations. Stakeholder consultation under this Program showed that comprehensive utilization rate of major crop straws in Hunan aims to reach over 88 percent, of which nearly 60 percent will be used as fertilizers such as straw returning to the field, which promotes carbon sequestration in paddy soil.

94. **However, straw returning can significantly increase methane emissions, thus, co-management of water and straw at early rice growing stage is crucial.** Although straw returning has significant benefits in soil fertility improvement and carbon sequestration, returning organic materials, such as fresh crop stalks, can also significantly increase methane emissions from paddy fields. Under modern high-yield rice planting practices, especially under straw returning, methane emissions from paddy fields mainly occur in the early growth stage, accounting for more than 80 percent of the total emissions during the whole growth period.⁸¹ But if farmers change the traditional continuous flooding irrigation, and use alternate wetting and drying with the returning of fresh organic straws to allow seven to ten days of aerobic decomposition before transplanting, it will not significantly increased methane emissions, and can even have significantly lower emissions than the continuous flooding irrigation without straw returning.^{82, 83} Therefore, field water control at the rice seedling or transplanting stage is a critical period for methane emission reduction in rice fields. At present, in rice production, most of the water management methods in field production are to retain the water layer at the early stage of rice growth, which is not conducive to the significant reduction of methane emission.

95. **Deep returning of rice straw will further reduce methane emissions and benefit rice growth.** Research, field visits, and farmer consultations showed that, under the traditional straw shallow rotary tillage, a large amount of straw is retained in on the surface or within a shallow depth (<10 cm) of soil, which hampers the growth of rice roots and leads to the risks of yield reduction. The decomposition of straw residue within a shallow soil layer under flooded condition will significantly increase methane emissions and generates reductive substances harmful to rice roots and environment. Therefore, it is recommended to change from the traditional paddy cultivation with shallow rotary tillage and flooding into the cultivation into the new cultivation with deep plough tillage or deep rotary tillage with around seven to ten days of drying before transplanting. The new measure will benefit rice growth and further reduce methane emissions. The returning of decomposed straw residues can also reduce methane emissions. However, in Hunan Province with tight rotation of double-cropping rice or rice-oilseed double-cropping areas, there is no enough time for the pretreatment of straw and green manure. Therefore, when organic materials such as straw and green manure are returned to the field, it is recommended to implement integrated practices: i) deep rotary tillage or deep plough tillage with straw application; ii) water control for seven to ten days during early stage of rice growth; and iii) select decomposed organic materials and return them to the field.

96. **The co-management of water-straw-fertilizer is critical to reduce rice GHG emissions.** The application of decomposed organic materials, such as compost, biogas slurry and biogas residues, and commercial organic fertilizers significantly increased the content of soil organic matter without

⁸¹ Jiang Y. et al., 2019. Acclimation of methane emissions from rice paddy fields in response to straw incorporation. *Science Advances*, 2019;5. ([link](#))

⁸² Hang X. et al., 2014. Differences in rice yield and CH₄ and N₂O emissions among mechanical planting methods with straw incorporation in Jianghuai area, China. *Soil and Tillage Research* 144, 205-210

⁸³ Linquist B. A. et al., 2015. Reducing greenhouse gas emissions, water use, and grain arsenic levels in rice systems. *Global Change Biology*. 21, 407-417. ([link](#))

accelerating methane emissions from rice paddy.⁸⁴ It is important to optimize water and straw co-management for rice methane emission reduction. The use of organic fertilizer and straw returning can also reduce the application of chemical fertilizer. Hunan HSFCP promotes various soil fertility improvement activities, such as fertilizer deep application, straw returning, organic fertilizer and green manure utilization, to further reduce the application of chemical fertilizer. In addition, drying rice paddy can significantly reduce methane emissions, but it may increase the emissions of nitrous oxide. Although the overall nitrous oxide emission is low,⁸⁵ the timing of drying and the methods of fertilizer application can be further optimized to reduce methane emissions, maintain low nitrous oxide emissions, and improve fertilizer use efficiency. Thus, the co-management of water, straw and fertilizer can significantly reduce the overall GHG emissions from rice paddy, including the reduction of methane and nitrous oxide emissions and the increasing of soil carbon sequestration.

97. Rice Methane Methodologies and MRV (Measurement, Reporting and Verification) Protocol Development. The Paddy Rice Program aims to use the “CDM’s (Clean Development Mechanism) AMS-III.AU methodology” whereby the rice farms follow alternate wetting and drying (AWD) method and aerobic rice cultivation methods. The proposed Program focuses on promoting a package solution of optimized water-crop straw-fertilizer (or nutrient) management, which fits well with the CDM’s AMS-III.AU methodology. The additional fertilizer management activities will help reduce nitrogen oxide emissions under the Program.

98. Rice cultivation has significant methane abatement potential. The UNEP Global Methane Assessment states that methane emissions from rice cultivation could be reduced by 6–9 Mt/yr.⁸⁶ According to an analysis by CCAFS, among the top 10 countries with highest mitigation potential for rice cultivation, four countries (Bangladesh, Indonesia, Vietnam, and Pakistan) have mentioned rice mitigation actions in their updated Nationally Determined Contributions (NDCs). China, the biggest rice producer, released a policy guidance last year on cutting methane from rice farming as new planting methods and technologies are being tested in the field⁸⁷. While the mitigation actions identified in the updated NDCs are not yet quantified, there is a significant opportunity to implement these mitigation actions through innovative financial schemes tied to robust MRV systems.

99. Key Features of Rice Methane Methodologies. There are six main standards that quantify emissions from the rice sub-sector: UNFCCC’s Clean Development Mechanism (CDM)⁸⁸, California Air Resources Board (CARB) Compliance Offset Protocol, Gold Standard, Verra, Climate Action Reserve (CAR) and Japan’s Joint Crediting Mechanism (JCM) that recently approved the J-Credit Methodology for Paddy

⁸⁴ Feng J. et al., 2013. Impacts of cropping practices on yield-scaled greenhouse gas emissions from rice fields in China: A meta-analysis. *Agriculture, Ecosystems & Environment* 164, 220-228. ([link](#))

⁸⁵ Jiang Y. et al., 2019. Water management to mitigate the global warming potential of rice systems: A global meta-analysis. *Field Crops Research* ([link](#)). Jiang et al. 2019 found that, on average, AWD increases the emissions of nitrous oxide by 105 percent. However, the overall nitrous oxide emission is low, contributes to around 12 percent of the GWP. The increased GWP by the increasing of nitrous oxide emissions is much lower than the decreased GWP by the reduction of methane emissions.

⁸⁶ United Nations Environment Programme and Climate and Clean Air Coalition (2021). *Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions*. Nairobi: United Nations Environment Programme.

⁸⁷ Zhijian, X. (2023, February 23). Chinese rice farming trials cut methane emissions. *China Dialogue*. Retrieved March 9, 2023, from <https://chinadialogue.net/en/food/chinas-rice-farming-trials-cut-methane-emissions-and-increase-yields/>

⁸⁸ United Nations Framework Convention on Climate Change. CDM Methodology AMS-III.AU Small-scale Methodology: Methane emission reduction by adjusted water management practice in rice cultivation. Version 04.0

Rice Cultivation⁸⁹. Gold Standard⁹⁰ and Verra both follow CDM's *Methane emission reduction by adjusted water management practice in rice* (AMS-III.AU) methodology though Verra has recently paused the use of CDM methodology for review⁹¹. Also, to note here is that the American Carbon Registry (ACR)'s *Emission Reductions in Rice Management Systems* is currently inactive⁹² and Gold Standard has announced that it is working on publishing a revised version of the CDM AMS-III.AU methodology, which was published for consultation last year⁹³.

100. CDM's AMS-III.AU methodology includes rice farms that (1) change the water regime during the cultivation period from continuously to intermittent flooded conditions and/or a shortened period of flooded conditions (2) follow alternate wetting and drying (AWD) method and aerobic rice cultivation methods and (3) that change their rice cultivation practice from transplanted to direct seeded rice. The methodology relies on reference field approach to quantify GHG emissions. Alternatively, emission reductions can also be calculated using IPCC tier 1 approach or default values.

101. The CARB *Compliance Offset Protocol Rice Cultivation Projects*⁹⁴ also includes rice farms that follow AWD practices, but in addition includes practices such as dry seeding and early drainage. The methodology uses Denitrification Denitrification-Decomposition (DNDC) biogeochemical process model for soil dynamics and emission factors for secondary emissions. CAR's *US Rice Cultivation Version 1.1*⁹⁵ methodology includes rice farms that practice dry seeding with delayed flooding and post-harvest rice straw removal and baling. This methodology also uses the DNDC biogeochemical process model for soil dynamics followed by emission factors for cultivation equipment and crop residue management and baling emission factors for crop residue baling. And finally, Japan's *J-Credit Methodology for Paddy Cultivation* extends the 'mid-drying' session for seven days or more during the rice cultivation period to assess the exact reduction of methane emissions.

102. Gold Standard has generated an estimated 952,990 credits across the three projects⁹⁶ in Pakistan, India, and Thailand (but not yet issued) and Verra (before the pause) had issued Verified Carbon Units (VCUs) totaling 4.56 million or 0.43% of all VCUs across 37 projects in China. On the other hand, the first pilot under CAR's methodology which was implemented across 2000 acres of land by seven growers in Arkansas, Mississippi, and California generated an estimated 600 credits. These credits were bought by Microsoft at an undisclosed price⁹⁷. (See methodology comparison in Table 16).

⁸⁹ Japan adds J-credit methodology for paddy rice cultivation " Carbon pulse. Carbon Pulse. (2023, March 1). Retrieved March 10, 2023, from <https://carbon-pulse.com/193900/>

⁹⁰ Gold Standard. Requirements to apply CDM methodology for Gold Standard certification. CDM Methodology – AMS.III.AU "Methane emission reduction by adjusted water management practice in rice cultivation"

⁹¹ Verra Pauses and Will Review the use of UNFCCC CDM Rice Cultivation Methodology. Verra. (2023, February 15). Retrieved March 6, 2023, from <https://verra.org/verra-initiates-review-of-unfccc-cdm-rice-cultivation-methodology/>

⁹² Inactive: Rice management systems. American Carbon Registry. (n.d.). Retrieved March 10, 2023, from <https://americancarbonregistry.org/carbon-accounting/standards-methodologies/INACTIVE-emission-reductions-in-rice-management-systems>

⁹³ Carbon Pulse. "UNDP, Switzerland defend rice farming methodology amid Verra decision to halt use." February 7, 2023

⁹⁴ California Air Resources Board. (2015, June). Compliance Offset Protocol Rice Cultivation Projects. Retrieved March 7, 2023, from <https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/protocols/rice/riceprotocol2015.pdf>

⁹⁵ U.S. Rice Cultivation Protocol. Climate Action Reserve. (2022, December 21). Retrieved March 10, 2023, from <https://www.climateactionreserve.org/how/protocols/ncs/rice-cultivation/>

⁹⁶ Gold Standard Impact Registry. <https://registry.goldstandard.org/projects>

⁹⁷ Gustin, G. (2020, December 7). U.S. rice farmers turn sustainability into carbon credits, with Microsoft as first buyer. Inside Climate News. Retrieved March 6, 2023, from <https://insideclimatenews.org/news/26062017/agriculture-rice-methane-emissions-carbon-trading-microsoft-climate-change/>

Table 16: Comparison of MRV Methodologies

	CDM, Gold Standard, Verra	CARB Compliance Offset Protocol	Climate Action Reserve (CAR)
Methodology Version/Name	Methane emission reduction by adjusted water management practice in rice (AMS-III.AU) Version 4.0	Rice Cultivation Projects	US Rice Cultivation Version 1.1
Scope/Activities	• Rice farms that change the water regime during the cultivation period from continuously to intermittent flooded conditions and/or a shortened period of flooded conditions. • Alternate wetting and drying (AWD) method and aerobic rice cultivation methods are adopted • Rice farms change their rice cultivation practice from transplanted to direct seeded rice.	• Dry seeding • Early drainage • Alternative wetting and drying	• Dry seeding with delayed flooding • Post-harvest rice straw removal and baling
Method for calculating emissions reduction	Using reference field approach. Alternatively, possible to use IPCC Tier 1 approach or default values	• Denitrification-Decomposition (DNDC) biogeochemical process model to quantify changes in N₂O and CH₄ emissions due to the eligible practices. • Emission factors for secondary emissions.	• Denitrification-Decomposition (DNDC) biogeochemical process model for soil dynamics. • Emission factors for cultivation equipment and crop residue management. • Baling emission factors for crop residue baling
Parameters to be monitored	• Baseline emission factor • Baseline emission factor for continuously flooded fields without organic amendments • Project emission factor • Aggregated project area (in a given season S, in a given year Y) • Cultivation period of rice using farmer logbooks (including sowing, water regime, yield, fertilizer, organic amendments,	Climate, soils, crop, tillage, use of synthetic fertilizer, manure amendment (if used), irrigation, flooding and draining, fuel usage, crop residue management parameters	Parameters are monitored at aggregate and field level: climate, soils, crop, tillage, fertilization, manure amendment (if used), irrigation

	crop protection application)		
Reporting & verification	Conducted based on samples of farmer logbooks	Documentation recorded by Offset Project Operator or Project Designee as per section 95976 of the Regulation	• Reporting periods generally correspond to a single year-long cultivation cycle. • Annual report for each cultivation cycle submitted by project developer that includes field's emission reduction calculation results for the current verified cultivation cycle (corrected and uncorrected)
# of projects using this methodology	Gold Standard: Three listed projects in Pakistan, India, and Thailand Verra: 37 in China	None	Two projects - one in California and one in the Midsouth including Arkansas and Mississippi
# of total estimated credits generated throughout the crediting period	CDM: None Gold Standard: 952,990 (across the three projects) but not yet issued Verra: 25 projects have issued VCUs (totaling 4.56 million, or 0.43% of all VCUs)	None	600 (across the two projects)

103. **Opportunities for Digital MRV (d-MRV).** Under the Paris Agreement, MRV systems are fundamental. Countries are required to measure and report their GHG emissions as well as their NDCs and determining either will require a robust MRV system. While time-consuming and costly, MRV systems of agricultural emission has matured over time thanks to the continuous innovation in satellite imagery, Artificial Intelligence (AI) and machine learning. This cost-curve continues to trend downwards.

104. In a conventional MRV system, project data is often recorded manually and stored as a hard copy or in an excel worksheet. This is both difficult to analyze for reporting purposes and costly to verify. D-MRV systems use emerging digital technologies such as smart meters, remote, sensors, and even satellite data to digitally report, record, and analyze project information. This increases the reporting accuracy, reduces the time required for data collection, and lowers the cost of 3rd party verification of the project's performance. D-MRV systems are a key component in future climate markets to ensure robustness and the smooth functioning of those markets.⁹⁸ There is a significant opportunity here to leverage technology to develop end-to-end platforms that connects MRV with carbon payments.

105. **The rapid development of remote sensing techniques provides opportunities to directly measure methane emissions from rice paddy.** The data from the European Space Agency's Sentinel-5P satellite platform provides reliable information on global methane emissions at high levels of spatial

⁹⁸ World Bank. 2022. Digital Monitoring, Reporting, and Verification Systems and Their Application in Future Carbon Markets. World Bank, Washington, DC.
<https://documents1.worldbank.org/curated/en/099605006272210909/pdf/IDU0ca02ce8009a2404bb70bb6d0233b54ffad5e.pdf>

resolution.⁹⁹ A new World Bank database¹⁰⁰ of monthly atmospheric methane concentrations was recently launched, with the high-resolution spatial grid calculated from data provided by the European Space Agency's Sentinel-5P satellite platform. It also illustrates the potential utility of the database with a global study of methane emissions from irrigated rice production.¹⁰¹ A comparative analysis suggests that the Sentinel-5P methane data can supplement the Emissions Database for Global Atmospheric Research data with more fine-grained spatial information, which may be used to measure, verify and reward methane reduction from rice paddy. This Program collected the Sentinel-5P methane emission data from the rice paddies in Hunan Province, and analyzed the monthly averaged results from Year 2019 to 2022 for the major rice production municipalities in Hunan by municipalities (Table 17).

Table 17: Atmospheric Methane Concentration for Rice Production Areas in Hunan (unit: ppb)

ADMIN	YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Changde	2019	1871	1868	1898	1889	1882	1933	1919	1902
Changde	2020	1885	1882	1905			1895	1939	1936
Changde	2021	1905	1906	1897	1922	1907	1906	1923	1934
Changde	2022	1901	1904	1921	1943	1886		1973	1943
Changsha	2019	1863	1868	1892	1890	1887	1916	1918	1894
Changsha	2020	1870	1881	1893		1883	1890	1949	1941
Changsha	2021	1894	1907	1891	1909	1899	1910	1920	1930
Changsha	2022	1899	1905	1923	1927	1867		1973	1940
Chenzhou	2019	1859	1859	1861	1867			1921	1904
Chenzhou	2020	1871	1881	1893		1880	1923		1930
Chenzhou	2021	1872	1909	1892	1912	1896	1910	1917	1916
Chenzhou	2022	1888	1905	1925		1860		1969	1943
Hengyang	2019	1859	1859	1863	1867	1863		1920	1903
Hengyang	2020	1871	1881	1893		1880	1922		1929
Hengyang	2021	1873	1910	1894	1912	1896	1909	1918	1916
Hengyang	2022	1888	1905	1924	1885	1860		1969	1943
Xiangtan	2019	1857	1857	1891	1859	1863		1908	1895
Xiangtan	2020	1871	1882	1885		1883	1904		1912
Xiangtan	2021	1895	1921	1912	1911	1893	1894	1925	1912
Xiangtan	2022	1887	1909	1916	1885	1857		1967	1934

⁹⁹ Brian Blankespoor, Susmita Dasgupta, Nagaraja Rao Harshadeep, Somik Lall, and David Wheeler. Eyes in the sky: tracking methane through satellites to facilitate emissions reduction for climate mitigation. World Bank Blog. 2022. ([link](#))

¹⁰⁰ <https://datacatalog.worldbank.org/search/dataset/0062871>

¹⁰¹ Dasgupta, Susmita; Lall, Somik V.; Wheeler, David. (2022). Tracking Methane Emissions by Satellite : A New World Bank Database and Case Study for Irrigated Rice Production. Washington, D.C. : World Bank Group. ([link](#))

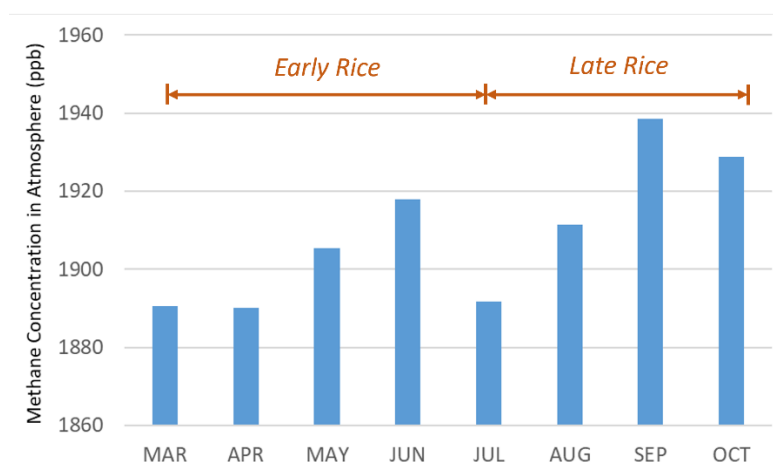
ADMIN	YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Yiyang	2019	1868	1868	1896	1891	1885	1926	1919	1899
Yiyang	2020	1879	1882	1900			1892	1943	1940
Yiyang	2021	1900	1906	1893	1916	1904	1909	1922	1934
Yiyang	2022	1901	1904	1922	1939	1879		1973	1942
Yongzhou	2019	1862	1880	1861	1867		1918	1911	1901
Yongzhou	2020	1871	1890	1893		1880	1910	1962	1938
Yongzhou	2021	1877	1923	1892	1906	1891	1939	1918	1907
Yongzhou	2022	1895	1912	1919		1870		1968	1943
Yueyang	2019	1864	1865	1888	1889	1882	1932	1917	1897
Yueyang	2020	1881	1880	1893			1894	1939	1926
Yueyang	2021	1897	1902	1896	1917	1913	1906	1918	1926
Yueyang	2022	1897	1900	1913	1933	1887		1966	1938
Zhuzhou	2019	1857	1857	1891	1859	1863		1908	1895
Zhuzhou	2020	1871	1882	1885		1883	1904		1912
Zhuzhou	2021	1895	1921	1912	1911	1893	1894	1925	1912
Zhuzhou	2022	1887	1909	1916	1885	1857		1967	1934

*Note: Data only for rice growing season (March to October). Some monthly satellite data is missing. (Source: World Bank Disruptive KIDS [Knowledge, Information & Data Services] analysis based on Sentinel-5P methane emission data.)

106. **Remote sensing-based methane emission data also revealed the importance of water saving practice and the needs of water-straw-fertilizer co-management.** The four-year averaged data during rice growing season for Changde city (including Hanshou county and Dingcheng district) is shown in Figure 11 as an example. Double-cropping rice is the common practice in Changde city, with the early rice growing from March to July and late rice growing from July to October. Water practice significantly impacted rice methane emission. Methane concentration was low in July, as farmlands were shortly drained for harvesting early rice. Methane emissions from late rice were higher than those from early rice, due to the water practice, straw returning and temperature. The straw residues from early rice were usually fully returned to field in July during harvesting, due to the very tight rotation schedule between early and late rice. Farmers get used to flood their fields after straw returning in July to accelerate straw decomposition. The decomposition of these fresh straws under anaerobic soil conditions during high or moderate temperature in August and September can significantly increase methane emissions. Thus, the timing of flooding and the techniques of straw returning and decomposition should be optimized to further reduce methane emissions and increase soil carbon sequestration. In addition, drying rice paddy can significantly reduce methane emission, but it may increase nitrous oxide emission. Thus, the timing of drying and the methods of fertilizer application should also be optimized to reduce methane emission, maintain low nitrous oxide emission, and improve fertilizer use efficiency. Therefore, the Program will promote water saving techniques to reduce methane emissions, but also highlight the importance of

water-straw-fertilizer co-management.

Figure 11: Methane Concentration in Changde City based on Remote Sensing Data from the Sentinel-5P Satellite (4-year Monthly Average, 2019-2022)



107. **Farmer consultation and stakeholder engagement was carried out the demonstration counties to understand farmers’ agronomic practices and behaviors and to gauge their willingness to adopt low-methane and water-saving technologies.** Majority of farmers have already practiced some extents of water saving techniques in the demonstration counties, especially drying during yellow ripening to facilitate harvesting. Even without subsidies, the farmers still expressed their willingness to embrace water saving techniques during the late stage of tillering, because they have a wide understand that wetting and drying regime during the late stage of tillering can help increase yields and enhance resistance to lodging and rice disease. But they also expressed the difficulties to practice frequent wetting and drying in some farmlands due to the lack of flexible irrigation and drainage systems and reliable water sources. Two demonstration counties in the Dongting Lake Plain Region (i.e., Dingchen and Hanshou) mainly rely on pumping for surface water irrigation. Thus, the farmers in these counties also have their own incentives to adopt water saving techniques to save water and energy. Very limited number of farmers practice wetting and drying regime during the early rice growing stage. Most farmers are not aware of the benefits to drain their fields during this stage. Farmers did not express huge concerns on the potential increase of weeding growing under AWD, as they usually apply herbicides effective to weed control. The field study and farmer consultation revealed a wide application of rice straw returning and green manure returning in Hunan. However, majority of farmers return rice straw and green manure within a shallow depth of soil (<10 cm) with shallow rotary tillage. The farmers usually received training and technical guidance on fertilizer application and straw management, but they have seldomly received training and guidance on water saving techniques. These farmers are practicing water saving techniques according to their own experiences, which can be further improved and optimized. Some farmers are reluctant to adopt new techniques, because they are not sure about the potential impacts on yields. Farmer consultation helped identify the opportunities and gaps to adopt mitigation measures, and further guided the Program design.

Results Area 3: Improving irrigation and drainage services for resilient rice production

108. **Results Area 3 aims to improve the sustainability of irrigation and drainage services for climate resilient production.** Previous high-standard farmland development in the 2010s in Hunan heavily focused on infrastructure investment and had less emphasis on O&M. The Hunan HSFCP includes a large area of high-standard farmlands to be upgraded and rehabilitated, as the irrigation and drainage

infrastructure, which had inadequate O&M, deteriorated quickly. Sustainable irrigation and drainage services consist of improved irrigation and drainage infrastructure, sustainable O&M funding, and enhanced O&M capacity. The assessment showed that current irrigation O&M cost recovery is at a relatively low level in Hunan, with a provincial average of around 50 percent, owing to low irrigation water tariffs and low to modest tariff collection rates. The Program will support the reform of agricultural water tariffs to ensure sustainable O&M funding. Several regulatory instruments and mechanisms will be established, including a water pricing mechanism, a water-saving reward mechanism, a precise budget support/subsidy mechanism, and a water use management mechanism. The Program will also empower farmer organizations in irrigation and drainage management. Hunan has been a leader in promoting participatory irrigation management—farmers are encouraged to join WUAs or farmer cooperative organizations to manage on-farm irrigation systems below tertiary canals. The Program will support the Government efforts to enhance the capacity and engagement of WUAs and farmer organizations in O&M in all the demonstration counties, including enhancing the role of women in these farmer organizations and WUAs. In addition, Hunan has started piloting water rights trading and Government buy-backs for water saved in several counties. The Program is expected to support extending these pilots into additional counties, which can provide additional incentives for adopting water saving techniques.

109. The Government has been pursuing comprehensive agricultural water pricing reforms since 2016.¹⁰² It is expected that agricultural water tariff reform can reasonably cover the O&M cost of water supply for irrigation. The key tasks of comprehensive agricultural water tariff reform include: (i) consolidating the foundation of agricultural water tariff reform, including improving water metering facilities, establishing agricultural water rights systems, improving agricultural water supply efficiency and benefits, promoting demand-driven irrigation water management, and enhancing the capacities of farmers and WUAs; (ii) establishing and improving pricing regimes for agricultural water use, including exploring different water pricing systems by quotas, cropping types, seasonal variability, and water sources; and (iii) establishing a targeted subsidy and water-saving incentive mechanism, including establishing a targeted subsidy mechanism for agricultural water use, developing a water-saving incentive mechanism, and promoting Public-Private Partnership in irrigation system development and management.

110. In 2019, a Notice on Accelerating the Comprehensive Agricultural Water Pricing Reform was issued.¹⁰³ The Notice summarized the emerging challenges and made clear requirements for establishing four mechanisms: (i) a pricing mechanism for agricultural water use, (ii) a mechanism for targeted subsidies and water-saving incentives, (iii) a mechanism for project construction and maintenance, and (iv) a mechanism for water use management. It also required that the provinces should allocate the task of comprehensive reform to cities and counties and promote the reform through a goal-oriented approach. The annual reform progress list was established, including the scope of reform implementation, the reform schedule and plan, and the implementation agencies. The specific reform measures of different regions are determined according to local conditions. The reform progress list is submitted to the NDRC, MOF, MWR, and MARA twice a year. The annual reform progress and the reform implementation plan for the next year is submitted by the end of each year.

111. Although the Government had established a clear pathway for agricultural water pricing reform, implementation in the Hunan Province still lags behind. Due to the relatively abundant water

¹⁰² State Council. 2016. Opinions on promoting agricultural water tariff comprehensive reform ([link](#))

¹⁰³ National Development and Reform Commission, Ministry of Finance, Ministry of Water Resources, Ministry of Agriculture and Rural Affairs. Notice on Accelerating the Comprehensive Agricultural Water Pricing Reform. 2019. ([link](#))

resources in Hunan, the deep-rooted traditional concepts of farmers, and the low awareness of water-saving and environmental protection, the implementation progress of the reform still lags behind. Therefore, in 2021, the Hunan Province issued the Options on Promoting Comprehensive Agricultural Water Reform¹⁰⁴ to accelerate implementation. Fourteen counties, including the PforR Program county of Hanshou, have been selected as demonstration counties for agricultural water tariff reform in the Hunan Province. All counties selected in the PforR Program have prepared implementation plans with annual reform targets allocated to townships or specific projects, permitting the PforR Program to further support the implementation of the agricultural water tariff reform. Field studies and stakeholder consultations in the demonstration counties showed that many irrigation districts have not collected agricultural water tariffs yet. In some districts with tariff collection, the collected tariff can only cover around 20 percent of the O&M costs. Even with the budget support from local governments, only 20 percent to 80 percent of the O&M costs can be covered. The gaps in funding for O&M have significantly impacted the sustainability of the systems.

112. There is strong governmental support for farmer organizations to engage in the management of irrigation and drainage systems. In 2005, the MWR, NDRC and the Ministry of Civil Affairs jointly issued the Opinions on Strengthening the Development of WUAs for Farmers, emphasizing the importance of WUAs for O&M. According to the Regulations on Agricultural Water Conservancy promulgated by the State Council in 2016, irrigation and agricultural water conservancy projects should be managed by irrigation management organizations, as well as WUAs, farmer cooperative organization, and farmers. According to the Comprehensive Agricultural Water Tariff Reform, WUAs, farmer cooperative organizations, and farmers who adopt water-saving measures and/or adjust cropping patterns to save water will be rewarded. In 2014, the Hunan Province issued Guiding Opinions on Strengthening the Development of Farmers' WUAs, which clarifies the basic principles of developing WUAs and their responsibilities. It also requires the governments at all levels to effectively support the development and capacity building of WUAs and to allocate funds to support O&M costs. These regulations will help support the capacity building activities under this Program. Field studies and stakeholder consultations in the demonstration counties found that the development of WUAs and farmer cooperation organizations is well advanced in Hanshou County, the pilot county for WUA management in Hunan. Over 65 percent of the irrigated areas are managed by the WUAs in Hanshou. However, in Dingcheng, irrigation and drainage facilities are mainly managed by village governments, rather than farmers or farmers' organizations. In other demonstration counties, the percent of irrigated areas managed by farmer cooperative organizations ranges from 15 to 30 percent. Most WUAs and farmer organizations do not collect agricultural water tariffs. The farmers, who usually cover only a small amount of O&M costs, rely heavily on budget support from the counties. It lacks clear O&M responsibilities and sustainable funding mechanisms for O&M.

113. China has introduced a number of policies to support the transfer of water rights and the buyback of water use rights and has successfully piloted water rights trading in different regions. The Comprehensive Pricing Reform of Agricultural Water requests the establishment of an agricultural water rights system. In 2022, the MWR, NDRC, and MOF issued the Guiding Opinions on Promoting the Reform of Water Rights,¹⁰⁵ which requires accelerating the allocation of initial water rights, promoting market-oriented trading, improving the trading platform, and strengthening the supervision of water rights trading. It is expected that, by 2025, the allocation of initial water rights will be established, regional water rights and water intake rights of water users will be clarified, the trading mechanism for water rights will

¹⁰⁴ Hunan Province, Options on Promoting Comprehensive Agricultural Water Reform, 2021. ([link](#))

¹⁰⁵ MWR, MOF, NDRC. Guiding Opinions on Promoting the Reform of Water Rights. ([link](#))

be further improved, market-based trading of water rights will become more active, trading supervision will be comprehensively strengthened, and a unified national water rights trading market will be initially established. The trading of water use rights should be promoted, and the trading of irrigation water rights should be conducted within irrigation areas or among water users or water organizations. If irrigation water users are willing to transfer their saved water use rights, the local governments at or above the county level, its authorized water administrative department, or the irrigation area management organizations may repurchase the saved water use rights and redistribute or trade it on the premise of meeting reasonable agricultural water demand within the region.

114. **The Hunan Province has piloted water rights trading and buyback.** In 2022, the PDWR and PDRC of the Hunan Province jointly issued a notice to control the total water amount and water use intensity in the 14th Five-Year Plan (FYP) period, which determined the total amount of water use control targets for each city in 2025. In 2022, the PDWR issued the Forecasting and Distribution Plan of Total Agricultural Water Use for the 14th FYP period, which clarified the total agricultural water consumption of each city under the condition of annual average precipitation in 2025. The cap on total water use and total agricultural water consumption lays the groundwork for water rights trading. From 2015 to 2017, a pilot reform of water rights was carried out in Jiangbei Town, Changsha County, and water rights in different sectors were confirmed and registered. From 2019 to 2021, the annual saved water rights buyback of Tongrenqiao Irrigation District in Changsha County was completed through the National Water rights trading platform for three consecutive years. The experience from these pilots can be used to guide the water rights trading activities in the demonstration counties under this PforR Program.

5.3 Implementation Arrangements for the PforR

115. **The proposed PforR Program will be implemented by Hunan province.** At the provincial level, a provincial program coordination group (PPCG) headed by the vice governor in charge of agriculture, comprising senior officials from DARA, PDRC, PDOF, PDNR, PDWR and PDEE, etc. as members will be set up to provide high-level coordination and strategic and implementation framework guidance; DARA will be the lead implementation agency for the Program while other departments are expected to contribute to the implementation of some soft activities. A provincial program management office (PPMO) hosted and led by DARA, with focal points from related sector departments, will be established to assist the PPCG and be responsible for day-to-day coordination of the Program implementation at the provincial level. The mission was informed that a technical support team has been appointed to support the operation of the PPMO. An expert panel will be established at the provincial level to provide in-depth expert advice to the Program preparation and implementation.

116. **Counties with dedicated County Program Management Offices (CPMOs) will be responsible for implementing the Program activities in the demonstration counties.** At the county level, a county program coordination group (CPCG) headed by responsible county leader and comprised senior officials from related sector departments will be established and a county PMO (CPMO) with a technical support team set up in each of the seven demonstration counties. The agricultural and rural affairs section will be the lead implementing agency at the county level while other related sector agencies are expected to implement the respective activities.

117. **Monitoring and Evaluation.** The two levels of PMOs (PPMO and CPMO) will be responsible for monitoring and evaluation of the implementation progress and results of the Program activities and the Program Action Plan (PAP) actions. An M&E plan will be prepared, specifying the unit of measurement, baseline value, targets, and data sources for each indicator, along with the methodology and responsibility

for data collection and reporting. The detailed M&E plan and a tailored expenditure and financial reporting system will be prepared and included in the Program implementation plan (PIP). Existing government systems based on the relevant technical guidelines applied by authorities will be used for results measurement. Reporting on the Program will be consolidated by the PPMO based on reports from the CPMOs and submitted to the World Bank for review. Technical assistance will be provided by the provincial program management office and its technical experts to the program counties in monitoring and reporting during the implementation stage. The PPMOs will prepare and submit semi-annual progress reports, M&E reports, mid-term review report, and a Program Implementation Completion and Results Report (ICR) by Program close. The PforR Program disbursement linked results (DLRs) will be monitored and verified by an independent verification agency.

5.4 Disbursement Arrangements

118. **The Bank would advance up to 25 percent of their total IBRD loan amounts to Hunan provinces by loan effectiveness.** After the DLIs against which the advances have been disbursed are achieved, the amounts of the advances will be deducted from the total amount to be disbursed against such DLIs. The Bank will record any amounts of advance as disbursed for an achieved DLR (“recovered”) after it has notified the MOF of its acceptance of the evidence of achievement of the results for which the advance was provided. The PPMO will be responsible for consolidating reports from participating agencies at the provincial and county levels and submitting them to the PDF.

119. The IBRD loan disbursements will be made periodically upon receiving and accepting the independent verification agency reports on the DLRs for the respective DLIs. The PPMO will submit a verification letter with the results to the World Bank and, upon acceptance of the verification results by the World Bank, the PDF will prepare disbursement applications and submit them to the World Bank. The applied disbursed amount will depend on the verified results. Some annual allocations are scalable and non-fixed, meaning that the Bank will disburse for over-performance up to the DLIs’ total allocation. Over-performance will enable the PDF to bring forward disbursements from Year 4 and 5 to Years 2 and 3. The PDF can apply for disbursements as soon as the province meets targets, provides the necessary evidence to the World Bank, and the World Bank accepts that evidence in a formal notice to the borrower with the disbursement amounts. The PDF can also request to be reimbursed for any results achieved beyond the indicative annual target up to and not exceeding the total PforR target and amount allocated for those DLIs that are scalable and confirmed by the World Bank.

5.5 Capacity Building

120. **Capacity building and technical assistance are necessary at both the provincial and county levels.** At the provincial level, capacity building for the development of strategic plan, technical standards, guiding documents and the MRV system are needed. Related experts (through the expert panel) and consultants will provide advice and support. Experienced technical support team will be engaged to assist with implementation management including implementation of the PAP actions (fiduciary, environmental & social, and technical) under the Program and internal monitoring and evaluation and reporting, and a third-party/independent verification agency for DLRs verification of the Program. At the county level, technical support and expert advice are needed for the reform activities of carbon trading and water right trading, as well as implementation of mitigation measures. At the community level, technical assistance may be required in engaging the WUAs and farmer organizations and empowering women’s participation and leadership in O&M, in addition to the envisaged comprehensive training on the low-methane and water saving technologies and agronomic practices. These capacity building and technical assistance

interventions (including support from the Bank team) will serve mitigation measures to reduce the risks associated with the technical design of the Program and institutional capacity for implementation and sustainability.

5.6 Program Economic Evaluation

The Rationale for Public Sector Financing

121. **The Program is expected to contribute to China's low-carbon agriculture development and generate substantial global public goods and strengthen provincial and county level institutional capacity for governance.** Substantial global public goods and climate co-benefits through (a) reducing greenhouse gas (GHG) emissions, in particular, methane, from rice fields; (b) improving natural resource (water and land) management and climate-resilience; and (c) reducing pollution from reduced use fertilizer and pesticide for rice cultivation. As such, the Program will contribute to the achievement of China's carbon peaking and carbon neutrality pledges. The lessons learned and knowledge generated from the Program would be relevant for addressing similar development challenges in other rice-growing Asian countries and beyond. In that sense, the Program also supports the Cross-Cutting Theme – Cooperating on Global Knowledge and Development of the CPF. The Program will also contribute to other global public goods by supporting food security, and enhancing biodiversity through the reduction of agricultural pollutants and water use. Furthermore, the Program will contribute to GPGs through knowledge management (sharing methodologies and approaches developed under the program). Finally, it will contribute to institutional development and improve the efficiency and effectiveness of public service delivery. This would be achieved through the development of frameworks or governance systems and capacity building at provincial and county levels.

Assessment Methodology

122. **The benefits of the Program include both global and local benefits** generated through (i) strengthening agricultural resources protection and use efficiency and improving production infrastructure to increase production capacity; (ii) improving irrigation and drainage systems and water management for resilient production; (iii) reducing agricultural NPS pollution and uplifting the production environment; (iv) enhancing ecological protection and restoration for sustainable production; (v) promoting green and low-methane technologies and practices for mitigating climate impacts; and (vi) improving institutions and capacity for O&M and sustainable services.

123. **Specifically, quantifiable benefits included in the analysis cover three aspects:** (i) at local level benefits will accrue from improved paddy quality, yield increases and input cost reduction in water, fertilizer and pesticide for rice cultivation, and (ii) substantial global public goods reducing greenhouse gas (GHG) emissions (CH₄ and N₂O) from rice fields. The program costs include all the incremental costs related to “high standard farmland construction” as per provincial government guidance, in addition to capacity building and extension costs under the Program.

124. **The economic assessment uses a Cost Benefits Analysis (CBA) based on the quantifiable benefits from rice production at local level and global benefit of GHG reduction.** The Program includes three Results Areas (RAs): RA1 - Strengthening government management system for sustainable development impacts; RA2 - Reducing GHG emissions for low-methane development; and RA3 – Improving irrigation and drainage services for resilient rice production. RA1 activities will be implemented largely at the provincial level, while RA2 and RA3 activities will be implemented at the demonstration county level. The

assessment implicitly combines activities under RA 1, 2 and 3 to value outcomes as a combined effort to achieve Program outcomes. RA 1 is regarded as facilitating outcomes achieved under RA 2 and RA 3. The CBA shows in Table 18 that farmers can save significant production costs in water, fertilizer and pesticide, while at the same time increasing their income through yield increase and rewards/payment for water saved. The carbon trading can bring in additional benefits. The analysis shows that rice farmers could gain incremental net income at around CNY 1,935/ha (US\$280/ha), and CNY 2,608/ha (US\$380/ha) with carbon trading benefits.

125. **The assessment compares a scenario of no government program to a scenario of a government program including World Bank support.** This approach is used because under a PforR, Government and World Bank funds are combined to achieve results, with no distinction at the activity level between World Bank-financed and Government-financed achievements. This approach can determine whether the overall program – of which Bank financing part-supports – is net socially beneficial.

126. **Net GHG emissions reduction is measured by the quantity of CO₂ equivalent emission reduction from the rice fields in the demonstration counties.** The GHG (CH₄ and N₂O) emission reduction is expected to come mainly from improved water and nutrient management including increase in soil carbon through returning crop straw to rice field, etc. The quantity has been estimated using the available tools until an MRV system is developed under the Program. The total carbon emission reduction for the Program for 5 years (Net GHG emissions reduction in demonstration counties is estimated, using the FAO Ex-ACT Calculation Tool for GHG emissions from paddy rice, to be about 2.4 million tons of CO₂ equivalent. DLI 1 will create the enabling environment to adopt mitigation measures to reduce rice GHG emissions. DLI 3 and 4 will promote the adoption of key mitigation measures (AWD and deep returning of straw) with capacity building and training. DLI 5 and 6 will provide sustainable irrigation and drainage services to create the conducive conditions for AWD, contributing to the reduction of rice GHG emissions.

127. **Economic Model (one hectare paddy rice production) in the demonstration areas has been formulated.** The incremental economic costs include investment costs for infrastructure improvement, technical package adoption, operational costs for agricultural production, and training and capacity-building costs. The major benefits included in the analysis are incremental crop production and price premiums from quality improvement; savings from reduced agricultural input costs (fertilizer, agrochemicals, diesel, and irrigation water); and benefits from GHG emission reductions. Other substantial positive externalities (e.g., improved soil quality and biodiversity are not included in the analysis as they are not easily quantifiable). The following assumptions have been applied for the analysis: (i) increased production and reduced inputs are based on the evaluation findings of the government agencies, complemented by the judgement from experts and extension workers; (ii) investment costs are in line with the standard unit cost norms as mandated by the provincial government; (iii) carbon shadow prices are set following the World Bank *Guidance Note on Shadow Price of Carbon in Economic Analysis* (November 2017);¹⁰⁶ (iv) program life of 20 years; (v) the discount rate adopted by the analysis is 6 percent, chosen according to guidelines from the NDRC, which is in line with the World Bank's guidance

¹⁰⁶ According to the World Bank's *Guidance Note on Shadow Price of Carbon in Economic Analysis* issued on November 12, 2017, projects' economic analysis should use a low and high estimate of the carbon price starting at USD 40 and USD 80 in 2020 and increasing to USD 50 and USD100 by 2030. The low and high values on carbon prices are extrapolated from 2030 to 2050 using the same growth rate of 2.25 percent per year that is implicit from 2020 to 2030, leading to values of USD 78 and USD 156 by 2050.

for discount rate;¹⁰⁷ and (vi) taxes, duties, and subsidies are not included as they represent transfer payments instead of real costs or benefits to society as a whole.

Table 18: Cost Benefit Analysis for Farmers' Incentives

Cost Benefit Analysis for Farmers' Incentives to Participate in the Program (CNY/ha)		
AWD (costs)	<i>Specific Activities</i>	<i>Incremental Costs</i>
	Electricity for drainage	450
	Labor cost	90
AWD total incremental cost (a)		540
AWD (benefits)	<i>Specific Activities</i>	<i>Incremental Benefits</i>
	Reduced electricity cost for irrigation	187.5
	Reduced cost for water charge for irrigation	225
	Government subsidies for reduced water use	37.5
	Reduced water use for water rights trading	225
AWD total incremental benefits (b)		675
AWD net benefits (b-a)		135
Fertilizer reduction cost savings		450
Pesticide use savings		180
Yield increase		1,170
Total incremental income (without carbon trading)		1,935
Carbon trading (12 tons/ha @ 56 Yuan/ton)		672
Total incremental income (with water and carbon trading)		2,608

(Note: The rice fields with better drainage condition can be gravity driven, which may not need electricity or energy for drainage.)

Results of the economic analysis

128. **Cash flows of benefits and costs for the model are projected over 20 years to estimate their economic rate of return (ERR).** The ERR with GHG reductions is estimated at 24 percent (at a low carbon shadow price), 34 percent (at a high carbon shadow price), and 14 percent at ERR without GHG reductions. These are all well above the discount rate of 6 percent, indicating that the Program is economically viable.

¹⁰⁷ World Bank. 2015. *Technical Note on Discounting Costs and Benefits in Economic Analysis of World Bank Projects*. The discount rate is recommended to be 6 percent for investments with long-term unquantified E&S benefits.

129. **No sensitivity test is warranted** because: (a) lower bounds of production increases and inputs reduction are used in the analysis throughout the program's life; (b) unit cost or investment of high standard farmland construction is virtually fixed by the provincial government; (c) significant unquantifiable positive externalities (soil quality and biodiversity improvement) are not included in the analysis.

130. **The Program will provide financial incentives for farmers' participation.** In adopting the AWD, deep application of nitrogen fertilizer and retention of paddy straw in soil, incremental costs will incur for more labor and energy input for drainage and deep ploughing; however, additional benefits will accrue from (i) reduction in chemical fertilizer use, (ii) less irrigation use resulting in less energy use and water charges; (iii) cash reward from ongoing government subsidies program for water savings against the set quotas; and (iv) the water right trading to be implemented in the Program implementation. Furthermore, all the stakeholders confirmed that adoption of these technical interventions will not reduce the crop yields and expected that the carbon trading, if materialized, will bring additional income to farmers. On balance, the farmers will gain additional net income at around CNY 130/ha (without carbon trading benefit) for adopting these technological packages, indicating the program will be financial attractive to farmers' participation. The main constraints identified by farmers and extension workers for the current low adoption are the unreliable water supply and drainage facilities, and lack of training and capacity building, all of which will be addressed squarely the program activities.

5.7 GHG Emission Mitigation

131. The GHGs emission reduction will mainly through three activities: i) AWD practice in the seven counties; ii) HSFC Practices, especially soil carbon sequestration; and iii) Organic fertilizer application. It will replace a certain percentage of chemical fertilizer, thus reduce GHGs emission. The **EX-Ante Carbon-balance Tool (EX-ACT)** estimated net emissions reduction by results area are presented in Table 5 below. Preliminary assessment shows that the GARR PforR will reduce approximately 479,391 tCO₂-e/year, or about 2,396,957 MtCO₂-e over its five-year implementation period. The assessment does not include the mitigation climate co-benefits generated from irrigation energy-saving, or improved institutional strategies, regulations, and plans. In addition, the estimated GHGs emission reduction presented herein are restricted to activities under the seven Program counties. Thus, these estimates could be considered to be conservative, especially given that there is huge potential for scaling up the program activities beyond the Program counties. The GHG emission reduction estimation will be done at the mid-term and the end of the Program (compared with the 2021 baseline values) in the seven demonstration counties, measured by metric tons of CO₂ equivalent. This approach would give the third-party IVA sufficient time to verify the results using the agreed protocols; and MRV methodologies.

Table 19: Estimated Ex-Ante Net Emissions Reductions by RA and DLI (Metric ton CO₂-e)/year)

Results Areas	DLIs	Project Interventions	GHG Reduction/year
RA2 - Reducing GHG emissions for low-methane development	DLI4	Increased rice areas adopting AWD technology and deep returning of straw	366,363
		Increase in new/upgraded high-standards farmland area in	111,068

		demonstration counties-especially soil carbon sequestration	
		Organic fertilizer (replacing chemical fertilizer)	1,960
Total			479,391

5.8 Gender Assessment

132. **Despite the feminization of agricultural labor in rural China, women are less represented in farmer cooperative organizations, which are playing key roles in local natural resource management.** Data (Figure 12) from the demonstration counties shows women can account for only 12.55 to 20 percent of the decision-making roles in the farmer cooperative organizations. As shown by Figure 13, the percentage of having women on management team in the farmer cooperative organizations in general range from 5 to 30 percent. Data from the China Health and Nutrition Study shows that the average share of farm work performed by women increased from 53 percent in 1997 to 59 percent in 2009.¹⁰⁸ The White Paper of "Gender Equality and Women's Development in China" in 2015 pointed out that women account for about 70 percent of the agricultural labor force.¹⁰⁹ In the past decades, a significant number of people have migrated from rural to urban areas in search for better paying jobs, and the majority of them were men. Women, especially those between the ages of 36 and 45, remained in the rural communities, spending more hours than men on the farm.¹¹⁰ Although women are crucial contributors to the agricultural production, it is still men who are the key opinion leaders in managing local public affairs and community governance. Factors such as the patriarchal line of power that bring about gender bias, gendered division of labor within and outside of the household, various informal customs/norms, and the interaction between institutions including the state, village and household¹¹¹ which produced gender disparities in ownership of land/properties all lead to the lower representation of women in governance of local natural resources and common goods.

133. **Farmers' cooperative organizations are effective vehicles in building a sense of shared purpose and enabling cooperative actions in sustainable natural resources management and development.**¹¹² Women participation in such organization is crucial for a green transition of agricultural practices, as trained women are more likely to adopt low-methane technologies than men evidenced by a study conducted in Hubei Province.¹¹³ Research also indicated the different typologies of tasks born by women and men involved in climate smart practices in rice cultivation, hence both genders should be included in communications and training.¹¹⁴ The gender differences in perceptions/knowledge of climate change and

¹⁰⁸ de Brauw, Alan. 2014. "Women and Agricultural Labor in China." In the Oxford Companion to Economics in China: 502-506.

¹⁰⁹ Information Office of the State Council of the People's Republic of China. 2015. Gender Equality and Women's Development in China. ([link](#))

¹¹⁰ International Food Policy Research Institute. 2012. The Feminization of Agriculture with Chinese Characteristics. Discussion Paper. ([link](#))

¹¹¹ Sargeson, Sally. 2008. "Women's Property, Women's Agency in China's 'New Enclosure Movement': Evidence from Zhejiang." Development and Change. 39(4): 641-665.

¹¹² Lu, Caizhen. 2008. "Why Is it so Difficult to Tackle Gender in Water User Associations? A Case Study from Gansu, China." European Association of Development Research and Training Institutes.

¹¹³ Liu, Yong, Jorge Ruiz-Menjivar, Lu Zhang, Junbiao Zhang, Marilyn E. Swisher. 2019. "Technical training and rice farmers' adoption of low-carbon management practices: The case of soil testing and formulated fertilization technologies in Hubei, China," Journal of Cleaner Production. 226: 454-462.

¹¹⁴ Brodsky, Alyssa "The Intersection of Gender, Climate Change and Rice Cultivation." Blog on Center for Gender Health and

water saving also make it important to fully address both genders' thoughts and proposals in governance.

Figure 12: Proportion of women in Farmer Cooperative Organizations

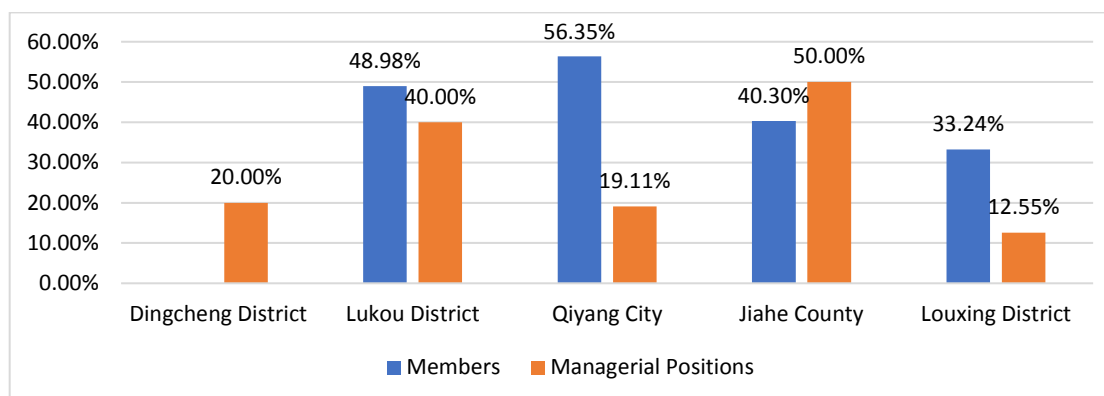
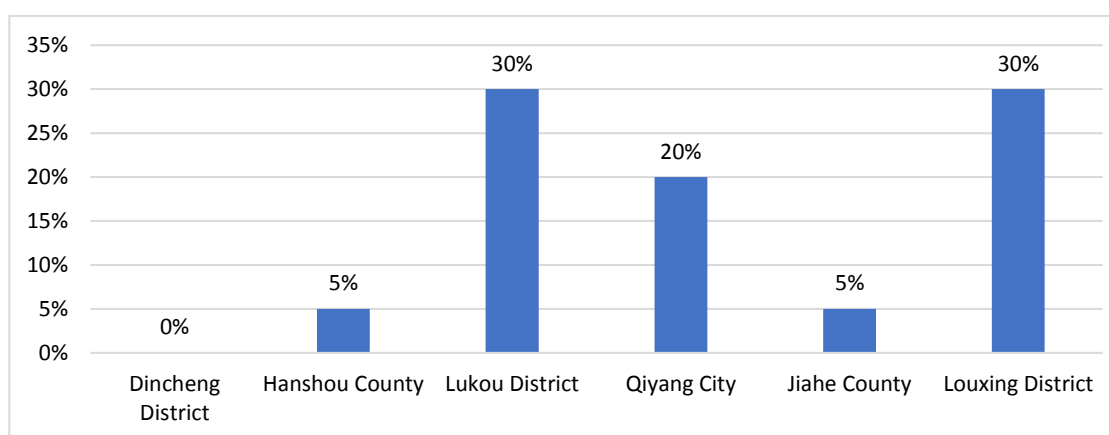


Figure 13: Percentage of farmer cooperative organizations with women on management team



134. **Fewer women engage in Water User Associations¹¹⁵, and the women's representation in management teams of WUAs is even lower.** Data from demonstration counties show that women account for around 44.53 percent on average in WUA members and 18 percent in WUA management teams (managerial positions). And women's presence in the irrigation management units is generally lower than men, women in general account for less than 30 percent in the technical/general positions, and the proportion of women in managerial positions can be low as 6.25 percent. The male-dominant culture, relatively low educational level and social skills of rural women, and their high domestic and productive workloads may all limit women's participation in WUA activities.¹¹⁶ Women's role in local water governance is further impacted by the long existing gender bias that men have better leadership capacity than women. The underrepresentation of women in WUAs showcases a missing opportunity for women's empowerment in the adoption of new and improved water-saving technologies. The result of a study on the gendered responses to drought in Yunnan showed that despite the increasingly active role of women in managing water during the drought, they are excluded from community-level decision-making on water. Given the importance of gender differences in perceptions of and responses to drought, efforts to support local resource management and climate adaptation will be undermined in the absence

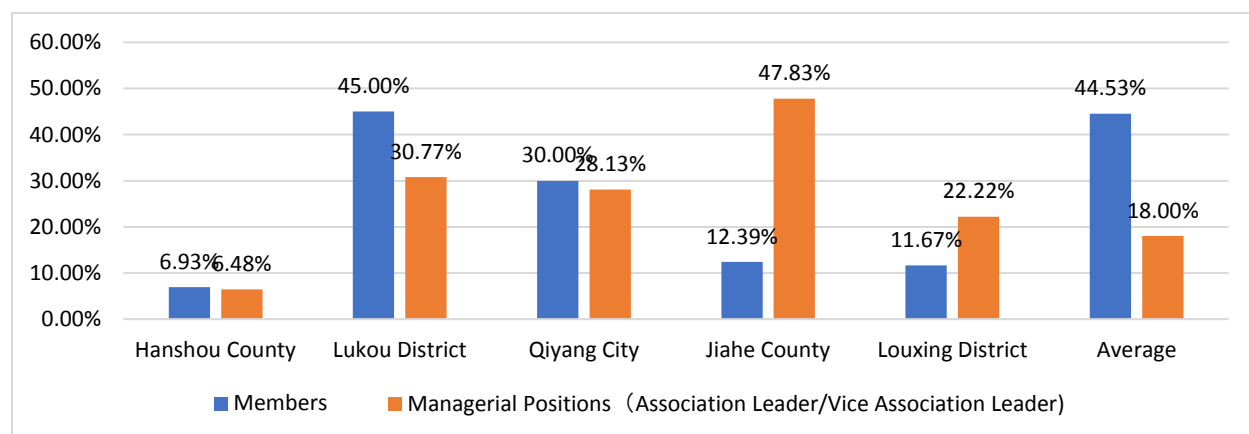
Equity Website. ([link](#))

¹¹⁵ Lukou District does not have WUA, the function is fulfilled by the village collective economic organization(村集体经济组织).

¹¹⁶ Lu 2008.

of women's perspective.¹¹⁷ In addition, the female rice farmers earn structurally less than male farmers in the six counties. Women's monthly earnings can be 68.05 to 84.35 percent of their male counterparts.

Figure 14: Proportion of women in Water User Associations



135. **Although women can be key agents of change in sustainable paddy rice farming, they lack training opportunities.** Data from the five counties shows that climate-smart trainings covered only a very small portion of the population, and the proportion of women included was much lower than that of men. This manifests a large gender imbalance considering the increasingly active roles of women in agriculture in China. Some counties have not yet conducted trainings on low-methane rice cropping package solution/technologies.

136. **Gender Actions.** To increase women's participation in local farmer's cooperative organizations and WUAs as decision-makers, the program will support the following gender actions:

- It will empower women participation and leadership in farmers' cooperative organizations and WUAs. For example, farmer cooperative organization/WUA membership should not be limited to registered landowners only [which are predominantly men], and the membership/advancement into management roles should not be linked with member's economic status.
- It will help local authorities in strengthening strengthen local people's gender awareness in irrigation management activities. This will include the development of gender equality trainings targeting both the management teams and members of farmer cooperative organizations/WUAs, staff from the irrigation management units and relevant government bureaus; cooperation with local women's federation in developing workshops/social activities for female farmers; working with local TV/Radio programs and actively using social media to feature women in the management of local natural resources and the spread of climate-smart agro-technologies.
- Targeted extension and training activities will be organized to enhance women's capacities on rice production, irrigation methods, water saving techniques and the adoption of climate-smart technologies, and also importantly, their leadership skills, preparing women with capacities and skills to lead and advocate for new technologies in rice production practices. Pre-training

¹¹⁷Su, Yufang, Suman Bisht, Andreas Wilkes, Neera Schstha Prahara, Yahui Zou, Song Liu, and Kevin Hyde. 2017. "Gendered Responses to Drought in Yunnan Province China." Mountain Research and Development. 37(1):24-34. <https://doi.org/10.1659/MRD-JOURNAL-D-15-00041.1>

surveys on both men's and women's training needs are necessary to ensure quality delivery of these training sessions.

6 PROGRAM ACTION PLAN

137. **The technical assessment has identified areas where capacity building is needed for strengthening the respective systems.** The Program Action Plan (PAP) focuses on the critical technical issues (Table 20 below). A range of technical issues and enhancement actions which were identified as detailed throughout the technical assessment, have been included in elements of program design rather than the PAP for a more targeted approach. The technical PAP actions include:

Table 20: Program Action Plan - Technical Items

Action Description	Source	DLI#	Responsibility	Timing		Completion Measurement
Develop a detailed trainer's manual for training farmers on low-methane rice production	Technical	DLI 3	DARA and PPMO	Other	By loan effectiveness	A copy of the training manual submitted to the World Bank
Develop/issue a provincial MRV standard for carbon sequestration and GHG emission reduction from rice production, in coordination with the GARR2 Program	Technical		PPMO and DEE	Other	By 2025	A MRV standard issued by the responsible provincial authority.
Prepare detailed implementation plans for carbon trading pilots	Technical		CPMOs concerned and PPMO	Other	In line with the pilot timelines in the Results Framework	A copy of the detailed implementation plans for carbon trading pilots submitted to the World Bank
Prepare detailed implementation plans for water right trading/buy-back pilots	Technical		CPMOs concerned and PPMO	Other	In line with the pilot timelines in the Results Framework	A copy of the detailed implementation plans for water right trading/buy-back pilots submitted to the World Bank

138. **Risk Management Framework for Technical Actions.** The operation has identified the risks associated with the technical aspects of the Program. A risk management framework for technical actions has been designed, addressing and cross-referencing the various identified risks and their mitigation

measures in this TA, the PAP and the PIP. In addition, the risks associated with the dependence of this Program on the development of MRV protocols under the GARR (Hubei and Hunan) have also been identified and a risk mitigation strategy agreed with the government counterparts. It is expected that the counties engaged under this PforR will be closed informed of and involved in the preparation and testing of the MRV protocols developed under the GARR (Hubei and Hunan) to identify any issues early and agree on the best course forward.

7 IMPLEMENTATION SUPPORT PLAN

139. The implementation of the Program will require continuous support and attention from the World Bank team. The PforR instrument is new to some government teams involved in the Program, and support will be provided to ensure all teams are acquainted with its requirements. This annex also outlines the key activities proposed to address risks identified by the risk assessment and provides an indication of the technical assistance and resources needed to improve the quality of Program implementation. Emphasis is placed on (a) supporting early-stage implementation and building institutional capacity, (b) reviewing implementation progress (including PAP implementation) and achievement of Program results and DLIs, (c) providing support to resolve emerging implementation issues, (d) monitoring the adequacy of systems performance and monitoring compliance with Legal Agreements, and (e) supporting the Government in monitoring changes in risks.

140. The strategy and approach for implementation support includes an emphasis on the technical, fiduciary, and E&S support needed during implementation. During the Program preparation, the World Bank team provided technical expertise—and will continue to do so during implementation—as well as guidance to the agencies on fiduciary and E&S aspects to ensure completion of the actions agreed in the PAP. Implementation support from the procurement and financial management team will focus on reviewing and monitoring compliance with the Government’s own systems and the actions defined in the PAP, while the implementation support will also provide technical assistance to address shortcomings identified during the assessment.

141. The Program implementation also requires expertise and technical assistance with PforR instruments during implementation. This support will be ensured through leadership and close contributions from team members in the China Country Office, in Beijing, with additional support and leadership from international technical specialists. This combination will leverage the World Bank’s global knowledge and local expertise to enable timely and effective responses to the needs of the borrowers. Formal implementation support missions and field visits covering all aspects of implementation will be conducted periodically during implementation. The characteristics of the Program necessitate that these implementation support missions will be longer than the standard single province or agency engagement. Tables 21 and 22 outline the estimated inputs from different specialists and resources required at different stages of Program implementation.

Table 21: Main focus of Implementation Support

Time	Focus	Skills Needed	Resources Estimate (Staff Weeks)
First 12 months	- Implementation of program management systems - Setting up cross administrative-level coordination mechanism	Core team, particularly technical, FM,	72

Time	Focus	Skills Needed	Resources Estimate (Staff Weeks)
	- Staff capacity building, on-the-job training on E&S and fiduciary - Procurement process and training - E&S training, support to implementation of requirements - Technical support to activities and implementation - Financial management and disbursement training and capacity building	- procurement, E&S experts - Integrated water and nutrient management expert	
12–48 months	- Technical support to implementation - Conduct regulatory and technical research - Review of environmental, social, and financial performance of central components - Continued improvements in project management systems including fiduciary and safeguards - Program Midterm Review	- Core team, particularly technical, FM, procurement, E&S experts - Integrated water and environment management expert	120
Other	- Completion of activities - Capacity building and facilitate knowledge exchange and events - Support technical and financial analysis of program investments - End-term evaluation and client ICR	- Core team, particularly technical, FM, procurement, E&S experts - Integrated water and environment management	56

Table 22: Task Team Skills Mix Requirements for Implementation Support

Skills Needed	Number of Staff Weeks	Number of Trips	Comments
Task team leader/program management	10 annually	Three in the first year, two thereafter	Internationally based staff
Task team leader(s)/program management	14 annually	Three in the first year, two thereafter	Country office-based staff
Procurement specialist	3–6 annually	Two per year	Country office-based staff
Financial management specialist	3–4 annually	Two per year	Country office-based staff
Operations specialist	4–6 annually	Two per year	Country office-based staff
Environmental specialist	3–4 annually	Two per year	Country office-based staff
Social specialist	3–4 annually	Two per year	Country office-based staff
M&E specialist	4–6 annually	Two per year	Country office-based staff

Skills Needed	Number of Staff Weeks	Number of Trips	Comments
Water expert (irrigation and drainage services, agricultural water tariff reform, and water right trading)	2–4 annually	Two per year	Consultant (national)
Agricultural expert (low-methane rice production technology)	2–4 annually	Two per year	Consultant (national)
Agricultural expert (farmer training and extension service)	2–4 annually	Two per year	Consultant (national)
Agricultural sustainable development expert (agricultural GHG emission monitoring, and carbon trading)	2–4 annually	Two per year	Consultant (national)