NDC Analysis for Vietnam's agriculture sector targets by 2030

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Contents

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Abstract

Production of rice is essential to Vietnam's economy but paddy rice production also contributes significantly to the nation's greenhouse gas (GHG) emissions. Rice production emitted 45 million tons of carbon dioxide equivalent ($MtCO_2e$) in 2010, equating to 18% of total national GHG emissions (Tran et al., 2019). A variety of options to reduce GHG emissions during the production of rice must be implemented to achieve Vietnam's Nationally Determined Contribution (NDC) and green growth strategies. One of the most promising options is alternate wetting and drying (AWD), an irrigation technique in which fields are irrigated and then allowed to dry out to a certain point before irrigation commences. This technique can reduce methane emissions by as much as 50% on average without a reduction in yield (Carrijo et al. 2017). We provide multiple project scenarios (MARD, 2016; Mai & Ngo, 2020; and Tran et al., 2019) to achieve this target under differing technology adoption baselines and with low to high infrastructure investment prospects.

Vietnam's NDC targets and contribution of the rice sector

Rice is planted on a total of 7.47 million hectares in mainly three seasons in Vietnam, namely the Jan-April Harvest (JAH), May-August Harvest (MAH) and September-December Harvest (SDH). It is estimated that the rice sector emits roughly 44.7 MtCO2e of GHG per year, accounting for 50% of total agriculture emissions (Tran et al., 2019). In its Intended Nationally Determined Contribution (INDC) submitted to the UNFCCC in 2016, Vietnam targeted to reduce 8%-25% of its agriculture emissions by 2030 compared to the Business as Usual (BAU) scenario with domestic resources and international support respectively. In the updated NDC submitted in 2020, these targets haven been raised to 9%-27% compared to the BAU scenario. This amounts to 6.8 MtCO2e (national support) and 25.8 MtCO2e (international support) of mitigation from the agriculture sector.

In the rice sector, the Ministry of Agriculture and Rural Affairs (MARD) and the Ministry of Natural Resources and Environment (MONRE) specified alternate wetting and drying (AWD) and mid-season drainage (MSD) as two of the key measures to reduce GHG emissions in rice production. Specifically, MONRE estimated that the transition from continuous flooding to AWD on 200,000 hectares with domestic resources would reduce 0.94 MtCO2e and 1,500,000 hectares converted to AWD with international support would reduce 9.36 MtCO2e per year[1] (Table 1). MARD issued the NDC implementation plan in agriculture which targeted to convert 200,000 hectares to AWD and 1 million hectares to MSD with domestic resources to reduce a total of 4.14 MtCO2e per year (Table 1)[2].

[1] MoNRE, 2015. Technical report: Vietnam's Intended Nationally Determined Contribution
[2] MARD.2016. NDC implementation plan in Agriculture (Document 7208/BNN-KHCN)

Table 1. NDC mitigation targets in the rice sector (MARD, 2016 and Mai & Ngo, 2020)

Funding	**Domestic investment**		**International support**
	Scenario 1	Scenario 2	Scenario 3
Total area (ha)	200,000	1,000,000	1,500,000*
Mitigation measure	Continuous flooding to AWD	Continuous flooding to MSD	Continuous flooding to AWD
Annual mitigation target by 2030 (MtCO2e)	0.94	3.2	9.36
Total in rice (MtCO2e)	**4.14**		**9.36**

* including 500,000 hectares with moderate infrastructure and 1 million hectares with poor infrastructure.

Suitability assessment for water-saving technologies in rice production

The MapAWD tool[3] was applied to determine the climatic suitability for practicing AWD and MSD to establish the potential target area. Figure 1 demonstrates the suitability level of rice planting areas, that concentrate mainly in two regions, namely the Red River Delta (RRD) and the Mekong River Delta (MRD). In MRD, water-saving technologies are climatically suitable in the first two seasons JAH (or winter-spring season) and MAH (or summer-autumn season); while in RRD, practicing AWD or MSD is only climatically suitable in MAH (spring rice). During the September-December Harvest (SDH) season, there is generally low to no suitability to practice these irrigation technologies as this is the wet season and water cannot naturally drain from the field to allow for controlled dry periods throughout the cropping season.

[3] MapAWD is a tool developed by IRRI to map the areas with different levels of climatic suitability to apply water-saving techniques for rice production based on bio-physical data (e.g., rice extent, cropping season, rainfall, potential evapotranspiration and soil percolation rates) and climate-risks and unfavorable soil information.

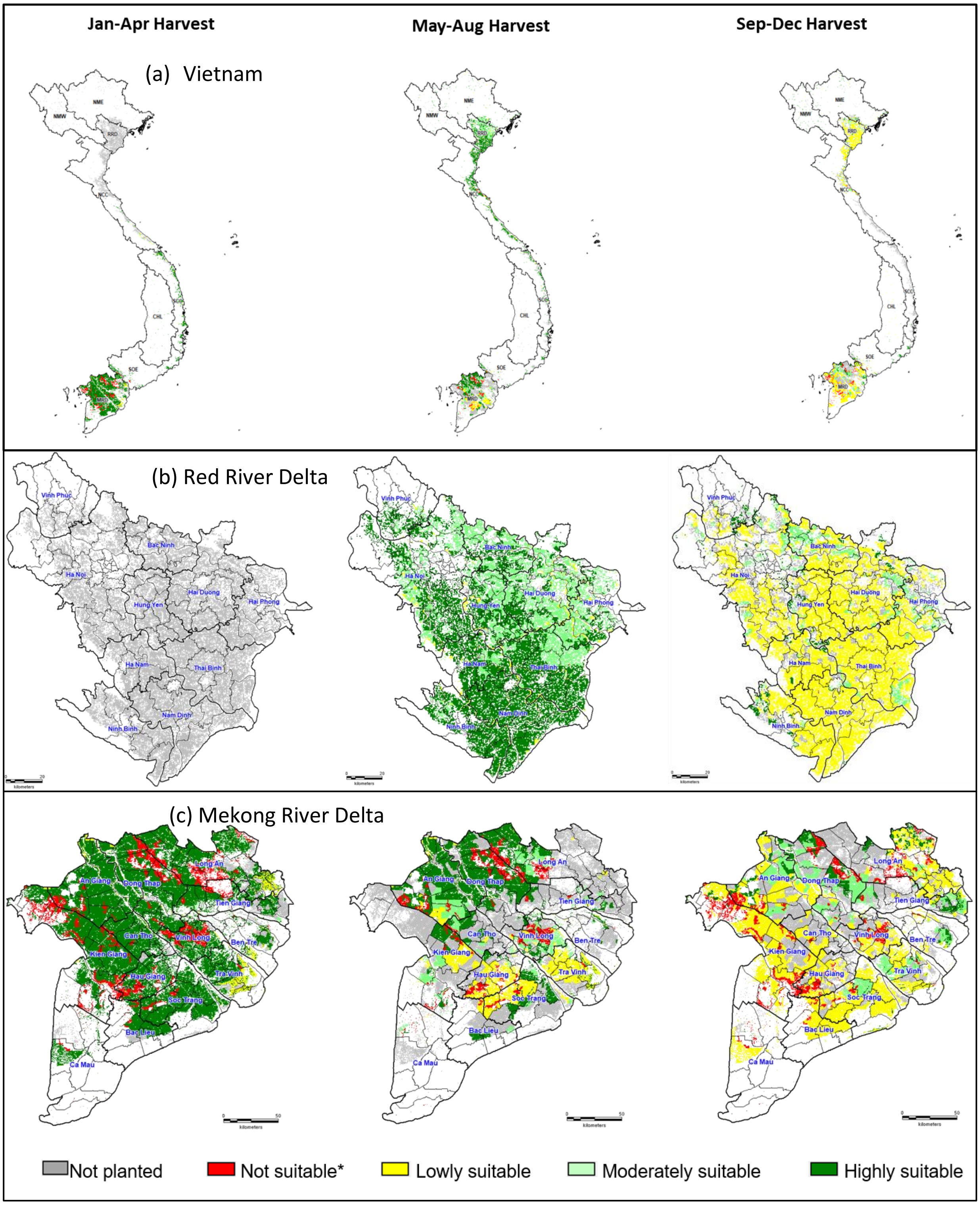

Figure1. (a) National map of AWD suitability in three cropping seasons; (b) map of AWD suitability in Red River Delta region; (c) map of AWD suitability in Mekong Delta River Region

For the first two cropping seasons, a total national area of 4.3 million hectares is suitable for AWD and MSD (see Table 2). Of this area, 510,000 hectares is only suitable for MSD because the existing infrastructure is not adequate for multiple times of drainage but can service one drainage in a season. The Red River Delta and the Mekong Delta make up 71% of the suitable area nationwide, therefore, our analysis will focus mostly on these two regions to target the transition to AWD on 1.7 mil ha (Scenario 1: 200k + Scenario 3: 1.5 mil) and to MSD on 1 mil ha (Scenario 2).

Table 2: Suitability are for water-saving technologies in rice production

Location	Suitability level/Practice	Potential area (ha)		
		JAH	MAH	Total
Nationwide	Moderate-High suitability (MSD/AWD)	2,022,050	2,289,220	4,311,270
Red River Delta	Moderate-High suitability (MSD/AWD)	-	688,775	688,775
Mekong River Delta	Moderate-High suitability (MSD/AWD)	1,626,890	727,177	2,354,067

Estimation of GHG mitigation potentials of water-saving practices

We use Tier 2 emission factors from MONRE (2014) to calculate the greenhouse gas emissions for the northern region of Vietnam (RRD) and for the southern region (MRD) using the SECTOR tool. SECTOR is a tool developed by IRRI to calculate GHG emissions from rice production based on the IPCC Tier 2 approach. With user-defined input data on rice production (i.e., cropping area, yield, and management practices), it calculates both onsite and offsite emissions by season. Table 3 shows the seasonal emissions for the RRD and MRD under traditional rice farming practices (i.e., continuous flooding) and under conditions where AWD and MSD irrigation are practiced.

Table 3. GHG emission factors and reduction potential

	RRD	MRD	
	MAH	JAH	MAH
Emission factors (kgCH4/ha/day)*	3.05	2.17	2.2
GHG emission per ha (tCO2e/ha)			
Traditional package	11.37	13.31	11.61
MSD	8.65	10.07	8.59
AWD	7.15	8.29	6.92
GHG emission reductions per ha compared to Continuous flooding (tCO2e/ha)			
AWD	4.22	5.03	4.69
MSD	2.72	3.24	3.02

*Source: MONRE (2014). Note: RRD MAH 123 days; MRD JAH 101 days; MRD MAH 99 days (season length Vo et al., 2020).

The estimations in SECTOR were made with assumptions on the production of rice based on previous studies. The standard baseline parameters used in SECTOR across both regions include pre-season water treatment non flooded less than or equal to 180 days before that season; residue incorporated shortly before (less than or equal to 30 days before) season; unless otherwise noted, organic amendments of 0.8t/ha residue incorporated (accounts for stubble); 100kgN/ha/season; and differing amounts of burned residue (see below for regional and seasonal specifications).

The parameters that are differentiated across the seasons include:

- Cropping duration: 123 days in MAH in RRD; 101 days in JAH and 99 days in MAH in MRD;
- Rice yield (using 2018 data from Vietnam's General Statistics Office): 6.5 t/ha in MAH in RRD; 7.2 t/ha in JAH and 5.3 t/ha in MAH in MRD (GSO, 2020);
- The traditional package is based on the assumption that current water management is continuous flooding;
- In RRD: the popular cropping rotation is Spring Rice - Summer Rice - Winter dryland crops, thus assuming no straw incorporation in the Spring rice (MAH) but straw produced by this season will be burnt 100%.
- In MRD: Assume 2.4t of straw from the previous season (SDH) is incorporated in the JAH season, while at the end of JAH season 5.76t of straw will be burnt. A remaining 2t of straw that was not fully burned is assumed to be incorporated into the MAH season and at the end of MAH season, 2.12t of straw is assumed burned.

Scenarios for NDC implementation and mitigation benefits

We combined the suitability analysis and GHG emission estimations to develop three scenarios of NDC implementation in the rice sector in line with the NDC targets in agriculture (Table 4).

Table 4. NDC implementation scenarios

Funding	**Domestic investment**				**International**	
Scenarios	**Scenario 1**		**Scenario 2**		**Scenario 3**	
Mitigation measure	AWD		MSD		AWD	
Season	JAH	MAH	JAH	MAH	JAH	MAH
RRD		50,000		230,000		320,000
MRD	150,000		400,000	370,000	830,000	350,000
Total area		**200,000**		**1,000,000**		**1,500,000**

Across all three scenarios, rice is planted in only one season in the Red River Delta (MAH) season, and two seasons in MRD (JAH and MAH). The combination of Scenario 1 (200k ha to AWD) and Scenario 2 (1 mil ha to MSD) represents the domestic contribution to meet the unconditional NDC target in agriculture. There are two more rice-related actions listed for the domestic contribution which include shifting from double or triple rice cropping to a rice-shrimp rotation on 200,000 ha and an additional 200,000 ha shifted to upland crops. For the internationally supported actions, there is an additional 1 mil ha listed for improvement to integrated crop management (ICM). We will briefly discuss these in the following sections but the main focus of the analysis is on the actions directly related to water management in rice production (i.e., AWD and MSD).

Putting the GHG emission factors from Table 3 into the SECTOR tool, we calculated the mitigation benefits under the three scenarios. The results of mitigation potential from converting traditional continuously flooded rice land to AWD and MSD are presented in Table 5 and depicted in Figure 2.

Table 5. Annual emissions reduction by 2030

Annual emissions reduction by 2030 (MtCO2e)	Scenario 1	Scenario 2	Scenarios 1+2	Scenario 3
IRRI's estimates of GHG emission mitigation	0.97	3.05	4.01	7.17
MARD's target from rice production	0.94	3.2	4.14	9.36

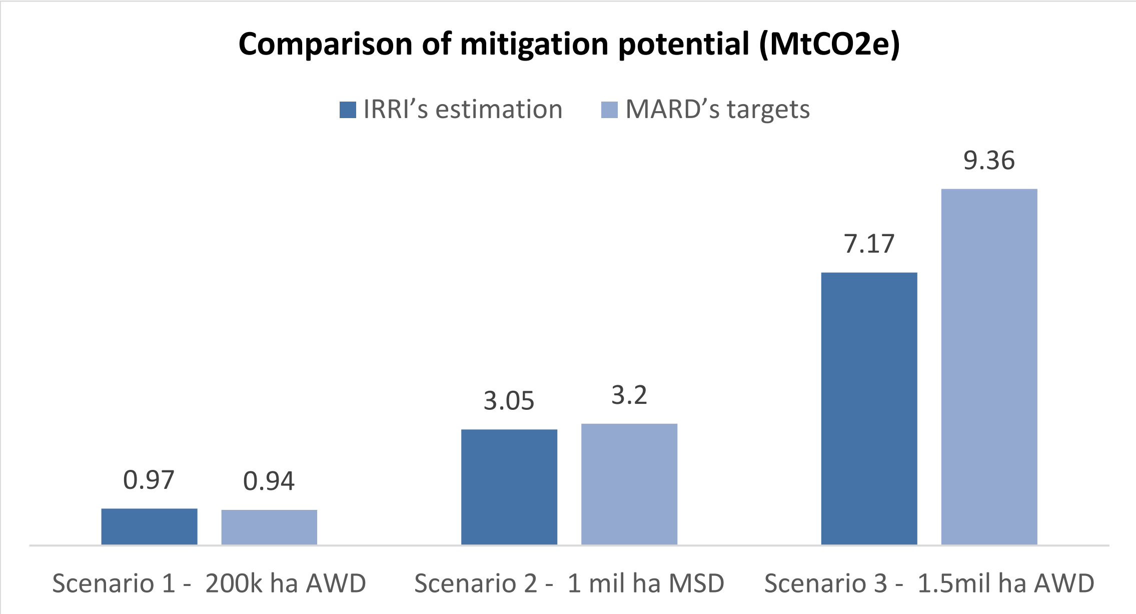

Figure 2. GHG emission reductions - IRRI's estimates and MARD's targets in 3 scenarios

Assuming the conversion rate (e.g., the rate of retention) has been accounted for in the investment budget, a total area of 200,000 hectares (Scenario 1) converted to AWD and 1,000,000 hectares converted to MSD (Scenario 2) over 10 years from traditional continuously flooded production at 10% per year will result in avoided emissions of 22.07 MtCO2e over the 10-year project period. According to our estimates, each year after this, 4.01 tCO2e will continue to be avoided in Scenarios 1 and 2 combined (domestic contribution). When coupled with the additional actions of converting 200k ha of double rice to rice-shrimp and 200k ha to upland crops, a further estimated 2.74MtCO2e annual emission reduction can be realized. Together, these actions supported by the domestic contribution will reach 6.8MtCO2e, thereby, satisfying the 9% reduction committed from the agricultural sector for the NDCs.

Similarly, the total CO2e abatement across the 10 years timeframe for Scenario 3 converting 1,500,000 ha from traditional to AWD will result in a reduction of 39 MtCO2e . The annual GHG mitigation potential by 2030 will be 7.17 MtCO2e per year.

The 6.8MtCO2e mitigation target by 2030 set forth in the scenario for domestic support, AWD and MSD has a high potential to meet mitigation targets specified in the NDC implementation plan. The remaining mitigation can be met by the conversion to rice-shrimp and upland crops (see Figure 3) (Mai, VT. and Ngo, DM.; 2020).

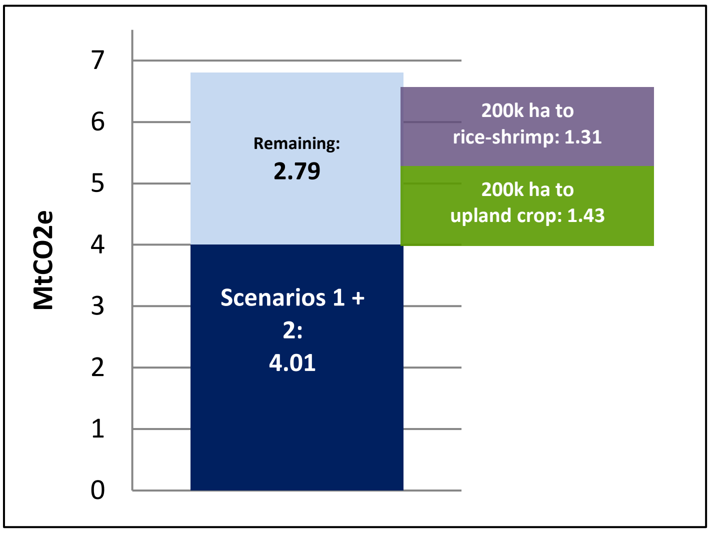

Figure 3. Annual mitigation by 2030 in case of domestic investment

However, when compared to the mitigation goals that were recently determined for the agriculture sector in Vietnam's updated NDC (2020), there are significant amounts of remaining mitigation to achieve, illustrated in Figures 3 and 4.

On the other hand, the mitigation in Scenario 3 (7.17MtCO2e) contributes roughly 28% of the internationally supported mitigation target in the agriculture sector (25.8MtCO2e). Additional NDC actions in rice include converting an additional 1 million hectares to integrated crop management (ICM) but this is expected to only reduce annual emissions by 0.5MtCO2e by 2030. Therefore, 18.13MtCO2e - a large percentage (70%) of the internationally supported mitigation target - will need to come from other agricultural actions (see Figure 4). This is a very ambitious target and will likely be difficult to achieve given the remaining agricultural mitigation options, such as replacing synthetic fertilizers with manure, and drip irrigation for coffee, do not yield as high of mitigation results as in rice and have higher relative costs for mitigation.

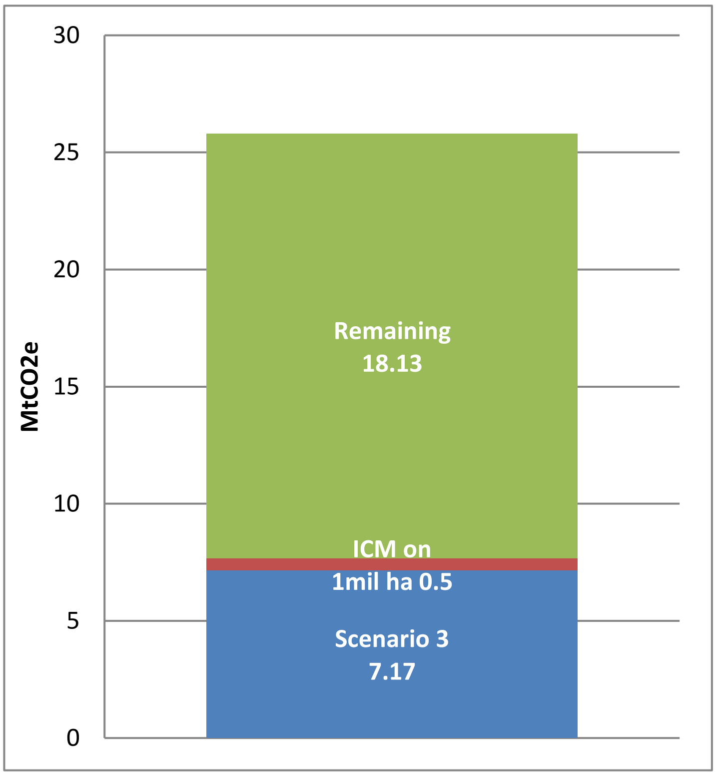

Figure 4. Annual mitigation by 2030 with international support

Another issue to consider is the use of emission factors in calculating GHG emission reduction. MONRE used the emission factors from MONRE (2014) to estimate GHG emission reduction potentials in Vietnam's NDC; therefore, this analysis adopts the same emission factors for consistency. A more recent set of emission factors have been developed by IRRI in cooperation with the Institute for Agricultural Environment (IAE) based on data from 36 field sites in Vietnam and are specific to the North, Central and South regions and for all respective seasons (Vo et al., 2020). Depending on the amount of area allocated to the Red River Delta versus the Mekong River Delta in the scenarios, this will have an effect on the mitigation potential as the original MARD and MONRE reports did not distinguish specific areas. The emission factors vary across regions thereby resulting in differing mitigation potential.

In Figure 5, the comparison between the MONRE (2014) emission factors and Vo et al. (2020) emission factors shows that the emission factors are lower than previously thought in the RRD MAH and MRD JAH, but higher in MRD MAH. It is likely that these updated emission factors may be used in the next iteration of NDC implementation. The implications of using the updated emission factors are that the reduction potential will be lower in the RRD MAH and MRD JAH which would have a greater negative impact than the increase in reduction potential from the change in MRD MAH because there is higher suitability for area that can be converted in MRD during the JAH season. This change in potential may affect the distribution of targeted area for conversion. These are all important factors to consider when planning that change the outcome and the project feasibility.

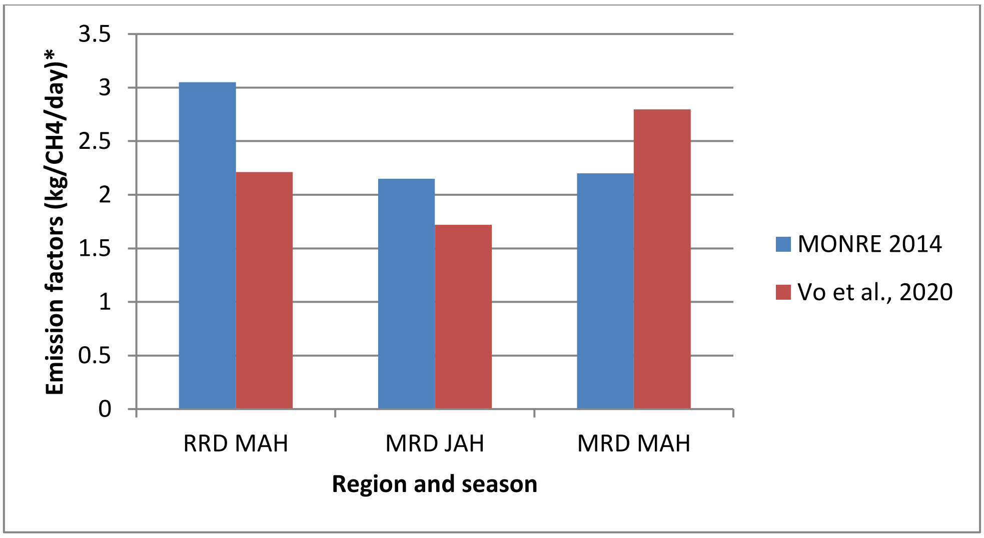

Figure 5. Comparison of emission factors between MONRE (2014) and Vo et al. (2020). Note: The season length from Vo et al. (2020) was used to calculate emission factors for both for equal comparison.

Although the more recent emission factors provide more accurate estimates it is advised that the use of emission factors is consistent in planning, monitoring, and evaluating NDC implementation towards 2030 to provide the estimate as accurate as possible. Therefore, the emission factors from MONRE (2014) were used with a global warming potential factor for CH4 of 25 to maintain consistency and for comparison.

Investment costs and benefits

The three scenarios are assessed using the cost and benefit analysis tool developed by UNIQUE Land Use and Forestry in cooperation with IRRI and MARD, aptly named *Cost Impact Analysis for*

Rice Emissions – COMPARE. This tool allows for the comparison of the following rice mitigation approaches: mid-season drainage; AWD; One Must do, Five reductions; Straw residue management; Fertilizer efficiency; Sustainable Rice Platform; and System of Rice Intensification which can all be compared to a business as usual scenario. Users can compare across mitigation options to evaluate the best option in terms of economic returns to the farmers and to investors (allows for capital and operational expenditure seasonally), environmental benefits (reduced carbon, water, and air pollution), costs over time, net present value, etc. The investment needs for each scenario were taken from MARD's NDC implementation plan and the investment guide by Tran et al. (2019). However, it should be noted that a more recent document from Mai and Ngo (2020) includes project costs that are considerably higher due to major irrigation infrastructure needs defined for 1 million ha of the 1.5 mill ha planned for AWD under international support. The remaining 500,000 ha allocated for transition to AWD under international support is assumed to have moderately adequate infrastructure that also needs improvements to irrigation infrastructure.

MARD originally targeted areas with adequate infrastructure to apply AWD and MSD to maximize the cost-benefit efficiency of domestic resources (Scenario 1 and Scenario 2). In Scenario 3 where international support is mobilized, AWD is outscaled to areas where the existing infrastructure is assumed to be moderate (500k ha) or poor (1 mil ha) and needs upgrading. Operational expenses (including monitoring and evaluation, research, and capacity strengthening) incur in all three scenarios.

Using the investment guide by Tran et al. (2019), the proposed investment to outscale AWD in the MRD to 2030 included hard infrastructure investment amounting to approximately $642USD per ha (80%) and operational expenses at $160USD per ha to $213USD per ha (20-25%) depending on whether the improved technique (AWD/MSD) is practiced in a single or double cropping. The farmers targeted for practicing AWD/MSD in two seasons yearly will incur lower operational costs in the second season because several operational activities happen only once per year. This makes a sum of $802-$855 per ha over the 10-year period. The capital expenditure for hard infrastructure is considered an upfront or one-time cost that is applied only to the physical land area (not the planted area), while the operational costs of $16USD-$21USD are annual costs dependent on practicing the improved management technique in one or two seasons. For comparison, the Mai and Ngo (2020) NDC implementation plan shows costs ranging up to $2075USD per ha for upgrading poor irrigation infrastructure to adequate for practicing AWD on 1mil ha. The detailed costs from our analysis using the estimated budget from Tran et al. (2019) are presented in Table 6.

Table 6. Investment costs in three scenarios

Investment	**Domestic**		**International**
Scenario	**Scenario 1**	**Scenario 2**	**Scenario 3**
Area	200,000	1,000,000	1,500,000
Mitigation measure	AWD	MSD	AWD
Infrastructure assumptions	Good existing infrastructure		Mix of moderate and poor
Capital expenses	NA	NA	$64.2/ha/year
Operational expenses	Training, MRV, research: $16/ha/year	Training, MRV, research: • 100% 1st season: $16/ha/year • 33% in 2nd season: $5/ha/year	Training, MRV, research: • 100% 1st season: $16/ha/year • 33% in 2nd season: $5/ha/year

Other assumptions made to produce the cost-benefit analysis include:

- Project timeline: 10 years
- Conversion rate of land area to AWD or MSD: 10% each year over a project period of 10 years
- Discount rate: 10%

The COMPARE tool allows automatic calculation of cost-benefit analysis indicators and GHG emissions according to the user's defined inputs. The tool has been populated with data on production costs and revenues collected from 989 farmers presented in McKinley et al. (2020), Nelson et al. (2020), Ong, (2019), and Tran (2019). The tool enables the development of two scenarios: "Business As Usual" (BAU) scenario (broadly reflecting the current method(s) of rice production) and a “Project” scenario (reflecting the desired transition to improved rice production methods) over an established project time period. The production costs/revenues, land use area, and project cost details are broken up by season for incremental transitioning and divergent cost structures in order to provide the most realistic conversion model. The COMPARE tool allows for quick calculation of the economic benefits, costs and GHG savings in each scenario and allows users to compare the results, which is useful for project planning and decision making.

Using the COMPARE tool and the available data, we analyze the beforementioned scenarios following the predetermined assumptions. The cost and benefits of each case including two scenarios are detailed in Table 7.

Table 7. Economic benefits in three scenarios

Funding source / Indicator	Domestic			International
	Scenario 1	**Scenario 2**	**Total domestic (1 + 2)**	**Scenario 3**
Investment cost (Million USD)	32	121	153	941
Annual benefit for farmers (Million USD/year)	8	5	13	57
Cost per ha (USD/ha)	160	121	127.5	627
Cost per ton of CO2e abated (USD/tCO2e)	6.0	7.2	7	24

Overall, the investment in low-emission technologies brings economic benefit to farmers from reduced production cost. There are several clear results from the analysis: 1) it is more cost effective to target areas in the MRD that can support AWD in 2 seasons during the year because the costs are relatively similar to only one season but the mitigation potential is twice as high; 2) the cost to benefit ratio is much higher where the existing irrigation infrastructure is already at adequate quality to practice AWD and/or MSD. The average cost to save one ton of CO2e in such area is $7USD/tCO2e, while it ranges from $24USD/tCO2e (Tran et al., 2019) up to as much as $95USD/tCO2e (Mai and Ngo, 2020) in areas where existing irrigation infrastructure requires upgrading to ensure water supply on demand.

Estimates show Vietnam currently has low water use efficiency compared to neighboring countries (see Figure 6) (World Bank, 2019). Efficient use of water is extremely important for a resilient agricultural landscape in the face of climate change as it is projected that Vietnam will endure increasing salinization in rice production zones, thereby reducing production potential significantly in the future. Irrigation infrastructure upgrading has multiple and widespread benefits. Upgrades in one region will benefit the entire catchment area rather than just the targeted area given the reduced use of water through AWD/MSD and increased water use efficiency due to modernized irrigation. In addition to facilitating mitigation activities in agriculture (AWD/MSD), upgraded irrigation infrastructure will increase water use efficiency which is an important climate change adaptation strategy for Vietnam. Calculating net future value will be an important next step to developing investment strategies for irrigation infrastructure upgrades.

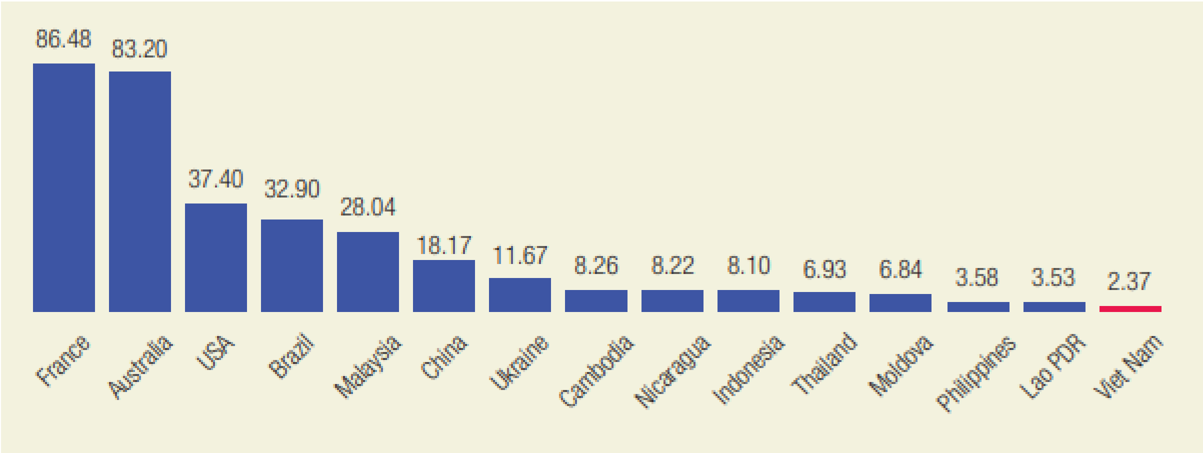

Figure 6 Water productivity per unit of water in selected countries ($USD of GDP). Source World Bank 2019.

In addition, interventions, especially capacity building on advanced production techniques can have a spill-over effect in the area. Therefore, it is highly recommended to select areas which currently have low adoption rates of the technologies to be introduced to maximize the benefits. Put differently, the project will have the highest possible results of scale, GHG mitigation, as well as economic, social and environmental benefits. This will mean a baseline assessment is necessary to target hotspots that have the highest potential for conversion both in total area and across multiple seasons to achieve the highest economic and environmental return for each dollar invested.

Another potential factor to consider is the conversion rate, or, in other words, the percentage of farmers that, once trained, will convert permanently to the introduced technologies (AWD and MSD in these scenarios). If there is a high drop-out rate, the operational costs to implement AWD are high because more farmers will need to be trained to achieve the same conversion rate. In such cases, introducing economic incentives from certified low-emission rice or from carbon credits where farmers receive additional funds to reduce emissions will be more likely to ensure farmers practice AWD and MSD and will reduce the overall operational costs because the conversion and retention rate will remain high. Introducing insurance schemes with irrigation service providers may also be a strong motivation given that fear of not having water when it is needed often is the barrier to practicing AWD. Insurance schemes based on hydrological water flows could ease risk for irrigation service providers and farmers.

Challenges

The analysis is based on the two fundamental assumptions. The first is that the entire targeted areas are irrigated in the conventional practice (continuous flooding). In other words, the baseline adoption rates of AWD and MSD in these areas are 0%. Thus, the project will achieve the full potential reduction of GHG emission at 4.01 MtCo2e and 7.17 MtCo2e with domestic and international funding respectively. The actual baseline which affects the ability to convert this target area, however, may look different. Take the example of An Giang province, one of the key rice production areas in MRD. The range of highly suitable and moderately suitable areas for water-saving technologies in An Giang province are relatively high (89.5% in JAH and 83.4% in MAH). However, an estimated 50% of the suitable area has already been converted to applying AWD or MSD. This means further mitigation potential in An Giang is limited because much of the area has already been converted (Figure 7). Therefore, having good baseline data is crucial to mitigation planning to select suitable areas and make investments purposefully.

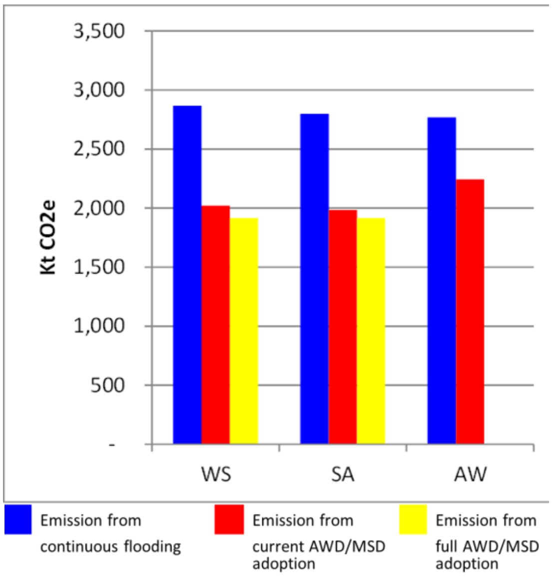

Figure 7. Emission scenarios in An Giang province

Next, the actual conditions of the existing irrigation infrastructure in rice planted areas are not well understood and documented. In Scenarios 1 and 2, we assume that the existing facilities for irrigation in the total 1.2-million-hectare area is adequate for applying water-saving technologies, based on the map of irrigated agricultural land area in 2001 jointly developed by Vietnam's General Statistics Office and the United Nations' Food and Agriculture Organization (GSO & FAO, 2001). The lack of accurate data on current conditions of irrigation infrastructure quality causes difficulty in targeting suitable areas and estimating the needed investment accordingly. The 1.5 mil ha that is targeted for international investment is assumed to have poor infrastructure on 1 mil ha and moderate infrastructure on 500k ha so the costs for conversion will be considerably higher than the domestic targeted area. Additionally, Vietnam has aging irrigation infrastructure and given that erratic and unpredictable weather becomes more frequent due to the effects of climate change, the availability and accessibility of irrigation water on time when it is needed may become more scarce leading farmers to convert back to continuous flooding in the face of uncertainty and increased risk. It is therefore critical to have reliable data on where the infrastructure is in poor, moderate, and good quality to inform better investment planning of mitigation options to realize the mitigation targets in rice.

Conclusions

Traditional continuously flooded rice production contributes significantly to methane emissions and the government of Vietnam recognizes the important role rice production plays in the national GHG emission budget. Water-saving irrigation techniques including AWD and MSD are proven to reduce methane emissions without reducing the yield or quality of rice. Therefore, the government has prioritized the outscaling of these technologies as the most promising short-lived climate pollutant mitigation technology to meet the NDCs for the rice sector.

Based on MARD's proposed plans for implementing NDC targets in the agriculture sector, we combine a set of three tools to analyze the GHG mitigation benefits and socio-economic costs and benefits of out-scaling AWD and MSD in RRD and MRD, the two largest rice production regions of Vietnam. At first, the SECTOR tool is employed to calculate the potential contribution to the GHG mitigation goal. The results suggest that about 59% (4.01 MtCO2e) of the unconditional agriculture goal (6.8 MtCO2e) can be met by converting 200,000 hectares of rice land under traditional irrigation to AWD and 1 million hectares to MSD (Scenarios 1 and 2). A remaining 40% (2.74 MtCO2e) can also be realized by other rice sector actions such as conversion to upland crops or to rice-aquaculture production. On the other hand, converting an additional 1.5 mill ha to AWD using international funds can satisfy only 28% (7.17 MtCO2e) of the unconditional target (25.8 MtCO2e). An additional 1 mill ha of Integrated Crop Management, as suggested by MONRE, would increase this reach to 30% of the unconditional target (0.5MtCO2e).

Altogether, this would mean targeting 4.1mill ha of rice to be under some type of transition to lower emissions. This represents more than half of the total rice area in Vietnam which is an ambitious undertaking. This transformation will require a massive coordinated effort across government sectors (agriculture, water management, and natural resource sectors), research institutions, bilateral and multilateral donors, implementing agencies, private companies, cooperatives, civil institutions (i.e., water user groups), and farmers. The remaining agricultural mitigation target of 18.13 MtCO2e/year (70%) by 2030 would need to be met by the other agricultural actions.

The analysis reveals fundamental issues to be addressed in NDC implementation planning. First, it is crucial to have a decent understanding of the baseline of current adoption of mitigation practices including AWD and MSD to target the right mitigation actions in the right areas, in order to achieve the expected mitigation. Second, the current conditions of infrastructure and investment needs should be surveyed thoroughly to inform proper funding plans and resource mobilization. NDC planning, implementation and monitoring should also consider the consistent use of emission factors to estimate accurately the progress as well as contributions by different stakeholders in various sectors and take care to avoid double counting. Additionally, by including other technologies that can also reduce emissions, such as straw removal for secondary use (composting, animal feed, mulch, etc.), the potential mitigation increases thereby reducing the per ton cost of abatement, but value chain costs would need to be considered.

References:

Carrijo, D. R., Lundy, M. E., & Linquist, B. A. (2017). Rice yields and water use under alternate wetting and drying irrigation: A meta-analysis. *Field Crops Research*, *203*, 173-180.

GSO. 2020. Data on rice yield in 2018, retrieved from https://www.gso.gov.vn/en/statistical-data/

GSO & FAO (2001). Agricultural Atlas of Vietnam, A Depiction of the 2001 Rural Agriculture and Fisheries Census. http://agro.gov.vn/map3/content/default_E.htm

Mai, VT (2020). Updated NDC, opportunities and challenges for agriculture. Presentation at Kick-off workshop of the project "Support to Vietnam for the implementation of the Paris Agreement". Hanoi, 22 October 2020.

Mai, VT; Ngo, DM (2020). Vietnam NDC Sectoral Report Agriculture. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Hanoi, Viet Nam

McKinley, J., Sander, B.O., Vuduong, Q., Mai, V.T., LaFrance, J. T. (2020). How Expectations, Information, and Subsidies Influence Farmers' Use of Alternate Wetting and Drying in Vietnam's River Deltas. *Submitted*.

MONRE. (2014). DMHCC—Department of Meteorology Hydrology and Climate Change of Ministry of National Resources and Environment (MONRE). Report on MONRE-JICA project "Strengthening capacity development for national GHG inventory in Vietnam". Available online: http://www.monre.gov.vn/English/Pages/Vietnam--Japan-strengthen-national-greenhouse-gas-inventory.aspx (accessed on 19 March 2020).

MONRE. 2015. Technical report on Vietnam's Intended Nationally Determined Contribution. Ministry of Natural Resources and Environment (MONRE). Hanoi, Vietnam.

Nelson K, Ong C, Duong VQ, Sander BO. (2020). Irrigation survey in MRD. Vietnam.

Ong C. (2019). Farmers' Preference for Improvement of Rice Straw Management in Mekong Delta, Vietnam. 10.13140/RG.2.2.21861.14562.

Thi Bach Thuong Vo, Reiner Wassmann, Agnes Tirol-Padre, Van Phuong Cao, Ben MacDonald, Maria Victoria O. Espaldon & Bjoern Ole Sander (2018) Methane emission from rice cultivation in different agro-ecological zones of the Mekong river delta: seasonal patterns and emission factors for baseline water management, Soil Science and Plant Nutrition, 64:1, 47-58, DOI: 10.1080/00380768.2017.1413926

Tran VT, Mai VT, Nguyen TDT, Le HA, Richards MB, Sebastian L, Wollenberg E, Vu DQ, Sander BO. 2019. An investment plan for low-emission rice production in the Mekong River Delta region in support of Vietnam's Nationally Determined Contribution to the Paris Agreement. CCAFS Working Paper no. 263. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: www.ccafs.cgiar.org

Vo, T. B. T., Wassmann, R., Mai, V. T., Vu, D. Q., Bui, T. P. L., Vu, T. H., ... & Sander, B. O. (2020). Methane Emission Factors from Vietnamese Rice Production: Pooling Data of 36 Field Sites for Meta-analysis. Climate, 8(6), 74.

Wassmann, R., Pasco, R., Zerrudo, J., Ngo, D. M., Vo, T. B. T., & Sander, B. O. (2019). Introducing a new tool for greenhouse gas calculation tailored for cropland: rationale, operational framework and potential application. *Carbon Management*, *10*(1), 79-92.

World Bank. 2019. “Vietnam: Toward a Safe, Clean, and Resilient Water System.” World Bank, Washington, DC.

The **Initiative on Asian Mega-Deltas** (AMD) aims to create resilient, inclusive and productive deltas, which maintain socio-ecological integrity, adapt to climatic and other stressors, and support human prosperity and wellbeing, by removing systemic barriers to the scaling of transformative technologies and practices at community, national and regional levels.

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