GUIDANCE ON INTERMITTENT IRRIGATION

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ABBREVIATIONS AND ACRONYMS

AWD	Alternate Wetting and Drying
DARD	Department of Agriculture and Rural Development of Viet Nam
FAWD	Farmers Simplified Alternate Wetting and Drying
GHG	Greenhouse Gas
ICT	Information and Communication Technology
IoT	Internet of Things
IRRI	International Rice Research Institute
JIRCAS	Japan International Research Center for Agricultural Sciences
LMB	Lower Mekong Basin
MAFF	Ministry of Agriculture, Forestry and Fisheries of Japan
MARD	Ministry of Agriculture and Rural Development of Viet Nam
MiDi	Midseason Drainage Followed by Intermittent Irrigation
MRC	Mekong River Commission
NDC	Nationally Determined Contribution
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

Rice farming in paddy fields in the Lower Mekong Basin (LMB) is one of the important economic activities and plays an integral part of supplying staple food, improving livelihoods of people living in rural areas, and ensuring food security.

On the other hand, the rice paddy farming has some constraints and negative effects to the environment. Growing rice in paddy fields requires a lot of water. In addition, methane (CH_4), one of the major greenhouse gases (GHGs), is emitted from the paddy fields.

Originally, since a long time ago, rice production in paddy fields has been done in a sustainable manner and in harmony with surrounding environment such as water, soil, and ecosystems. However, under conditions that socio-economic status is changing rapidly with population growth and needs to more rice production, it is necessary to address the climate change issues and further promote efficient use of water resources in order to enable the rice faming in the paddy fields to be sustainable over the future as well as improving productivity.

'Intermittent Irrigation' is featured as one of the solutions to these issues that rice paddy farming is facing. The Intermittent Irrigation is expected to contribute to reducing the amount of water use in rice cultivation and emissions of CH_4 from the paddy fields by properly practicing 'irrigation' and 'drainage' repeatedly in a plot of the paddy fields while growing rice.

This guidance explains basic methodology and effects of the Intermittent Irrigation based on results of research projects conducted in the LMB.

Multiple positive effects are expected on the Intermittent Irrigation. In particular, the effects on reduction of CH_4 emissions by conducting the Intermittent Irrigation are verified in a number of research projects, which is a field in which the rice paddy farming can contribute to tackling with the climate change issues as a way of the climate change mitigation.

On the other hand, conducting the Intermittent Irrigation could bring to farmers including women additional labor on the water level control in their plots of the paddy fields. Any incentive to the farmers is crucial to introducing the Intermittent Irrigation such as rice yield increase, reduction of irrigation pumping cost, development or upgrade of irrigation and drainage facilities, direct payment to the farmers for the reduction of CH_4 emissions. A funding source is required for developing or upgrading the irrigation and drainage facilities and for payment to the farmers. As the funding source, measures such as international or domestic carbon credit mechanism and access to the international climate funds could be options, which needs to be considered in the medium- and long-term perspectives.

The Intermittent Irrigation is a promising irrigation technique that could materialize a contribution to the climate change mitigation from agriculture sector through the rice paddy farming, modernization of agriculture, improvement of productivity, and efficient agricultural water use with higher water productivity by ensuring enabling environment of the Intermittent Irrigation.

The effects and methodologies of the Intermittent Irrigation are not unique and are different in each area due to its constraints and requirements, and according to local conditions

including agricultural practices, weather conditions, soil conditions, status of development levels of irrigation and drainage facilities. Particularly, for the effects of the Intermittent Irrigation, it is necessary to measure, evaluate and verify the effects in each area as well as to consider gender-sensitive approaches where the Intermittent Irrigation is applied.

In that sense, this guidance is a living document and to be revised and updated referring to and incorporating latest verification results of the effects and lessons learned from pilot projects of the Intermittent Irrigation applied in the LMB.

It is expected that the area of the rice paddy farming that is more sustainable, highly productive and with less the GHG emissions increase in the Member Countries through introducing the Intermittent Irrigation with modernization of the irrigation and drainage facilities.

1 INTRODUCTION

1-1 Background

Rice farming in paddy fields in the Lower Mekong Basin (LMB) is one of the important economic activities and plays an integral part of supplying staple food, improving livelihoods of people living in rural areas, and ensuring food security.

On the other hand, the rice paddy farming has some constraints and negative effects to the environment. Growing rice in paddy fields requires a lot of water. In addition, methane (CH_4), one of the major greenhouse gases (GHGs), is emitted from the paddy fields.

Originally, since a long time ago, rice production in paddy fields has been done in a sustainable manner and in harmony with surrounding environment such as water, soil and ecosystems. However, under conditions that socio-economic status is changing rapidly with population growth and needs to more rice production, it is necessary to address the climate change issues and further promote efficient use of water resources in order to enable the rice faming in the paddy fields to be sustainable over the future as well as improving productivity.

'Intermittent Irrigation' is featured as one of the solutions to these issues that rice paddy farming is facing. The Intermittent Irrigation is expected to contribute to reducing the amount of water use in rice cultivation and emissions of CH_4 from the paddy fields by properly practicing 'irrigation' and 'drainage' repeatedly in a plot of the paddy fields while growing rice.

1-2 Purpose of This Guidance

This guidance introduces an outline of the Intermittent Irrigation and describes knowledge and evidence on the Intermittent Irrigation that are acquired so far. In addition, this guidance shows requirements and conditions to introduce and practice the Intermittent Irrigation.

It is not always possible to introduce the Intermittent Irrigation in any paddy fields due to its requirements and conditions. However, the Intermittent Irrigation is a promising irrigation technique that is expected to save water and reduce CH_4 emissions in the paddy fields, and that could increase rice yield according to growing conditions.

This guidance aims to give useful information not only for benefits but also constraints and requirements for the government officers in the Mekong River Commission (MRC) Member Countries to consider introducing the Intermittent Irrigation in an area expecting the benefits and positive effects from practicing the Intermittent Irrigation.

In particular, for dissemination of the Intermittent Irrigation, it is to be desired that the Intermittent Irrigation be introduced verifying its detailed method and effects, and developing or upgrading required irrigation and drainage facilities in each area.

It is important to note that there is no common and unique methodology of the Intermittent Irrigation to be applicable to any area in the Member Countries. The methodology of the Intermittent Irrigation introduced in this guidance is a general methodology. The actual and detailed method of the Intermittent Irrigation is needed to adjust in each area according to conditions and status of irrigation and drainage, farming practices, and farmers' capabilities.

This guidance introduces a few practice methods on the Intermittent Irrigation considering applicability for local farmers. The applicability for local farmers is one of the most important factors to be considered when introducing the Intermittent Irrigation, which is a key to ensure sustainability and to benefit for a long term from the Intermittent Irrigation.

1-3 Intended Users of This Guidance

This guidance intends to be used by central or local government officers and policy makers who are engaged in the field related to the paddy rice farming and who consider to introduce the Intermittent Irrigation expecting for reducing CH_4 emissions, saving water, and probability of increasing yield on rice farming. This guidance is also expected to be used by the government officers and policy makers to consider policy measures on the rice farming to disseminate and promote the Intermittent Irrigation practice in the Member Countries.

2 RATIONALE OF INTRODUCING THE INTERMITTENT IRRIGATION INTO PADDY RICE FARMING IN THE MEMBER COUNTRIES

2-1 Methane is one of the Major Greenhouse Gases

The global temperature increased by 0.85˚C between 1880 and 2012. The atmospheric concentration of the GHG emissions in 2010 increased by 40% for carbon dioxide (CO_2), 150% for CH_4 and 20% for nitrous oxide (N_2O) compared with those in 1750. The CH_4 emissions from rice cultivation accounted for approximately 11% of global anthropogenic CH_4 emissions (33-40 Tg CH_4/yr) in 2000-2009 (IPCC, 2013).

Ninety percent of rice in the world is produced in Asia (FAO, 2018), and 90% of CH_4 emissions from the world's rice fields are from this region (IPCC, 2013).

Rice dominates crop production in the LMB countries, particularly in the lowland areas, with a total of over 23.1 million ha being cultivated in 2010. Between 1990 and 2010, the overall area of rice increased by 33% (MRC, 2018).

CH_4 is a short-lived climate pollutant with a lifetime of around 12 years, compared to several hundred years of CO_2. But the global warming potential of CH_4 is 28 times than that of CO_2, which means reducing CH_4 emissions can curb global warming with comparable quick effect (Nelson, 2022).

Therefore, reducing CH_4 emissions from rice fields is becoming important.

One of the Member Countries, Viet Nam, has made international commitments both to reduce the GHG emissions and to adopt green growth strategies across multiple sectors, including agriculture sector. The agriculture sector will play a critical role in meeting Vietnam's Nationally Determined Contribution (NDC), including commitments to the United Nations Framework Convention on Climate Change (UNFCCC) to cut CH_4 emissions by 30 percent by 2030 and achieve net-zero levels by 2050 as part of its 2021 United Nations Climate Change Conference (COP26) commitments.[1] The government's new Strategy for Sustainable Agriculture and Rural Development for 2021-2030 with a Vision to 2050, approved through the Prime Minister's Decision No. 150/QD-TTg of January 28, 2022, prioritizes resilient, green, low-carbon agricultural transformation (Shrivastava et al., 2022).

There is a realization that agriculture, with all its successes, is a major contributor to GHG emissions in Vietnam. It is the second highest emitting sector, accounting for about 19% of total national emissions (in 2020). About half (48%) of the agricultural sector emissions and over 75% of CH_4 emissions come from one single commodity, rice. Rice is Vietnam's most important staple crop, cultivated on over 54% of the land and much higher in the Mekong Delta and the Red River Delta. Rice provides food security to over 90% of the national population and contributes over 30% of total agricultural output. Vietnam now produces over 43 million tons of paddy (unprocessed rice), out of which the country exports on average over 6 million tons of rice (about 9% of global rice exports by volume), earning the country over

[1] In the updated NDC, the emission reductions targets were increased to 9 million and 27 million tCO_2e per year by 2030 for the unconditional and conditional targets, respectively (Shrivastava et al., 2022).

USD 3 billion in export revenue. In Viet Nam, significant reductions in rice production are challenging and impractical, as it is critical for food security, farmers' livelihoods, and exports. It is thus essential for Vietnam to transition to low-carbon rice production as a step toward sustainable low-carbon agricultural transformation (Shrivastava et al., 2022).

Viet Nam developed action plan for the National Strategy on Green Growth, which was outlined in **Box 1**.

Box 1. Action plan for the National Strategy on Green Growth in Viet Nam

The Ministry of Agriculture and Rural Development of Viet Nam (MARD) has approved an action plan for implementing the goals, tasks and solutions of the National Strategy on Green Growth for the period of 20212030, and vision to 2050.

Accordingly, agriculture will be steered towards sustainable, ecological, organic, circular development and low-carbon emissions in order to improve growth quality, increase added value and competitiveness, reduce environmental pollution in agricultural production and rural areas, and use effectively and efficiently energy and natural resources towards a carbon-neutral economy by 2050.

The sector has set a target that […] and at least 30% of total crop area will apply advanced and water-saving irrigation methods.

At the same time, the application of good agricultural production practices will be expanded to improve quality, added value and competitiveness as well as reduce the GHG emissions in agricultural production.

The process of new rural development must be accelerated to meet green and sustainable growth goals and form a lifestyle in harmony with the environment and nature.

The sector will promote the application of advanced production processes to reduce the use of fertilizers and chemical pesticides that cause environmental pollution and the degradation of arable land and the GHG emissions.

The ministry will also complete mechanisms and policies of promoting agricultural green growth and enhances human resource training for green and ecological agriculture, digital transformation and advanced technology applications serving the effective use of natural resources and environment protection.

In order to have investment capital for the green growth goals, the ministry focuses on mobilizing social resources, especially from businesses, and strengthening international cooperation to call for financial support and technology transfer in order to make Vietnam's agriculture a model for green, low-carbon, safe agricultural products, and improve competitiveness in the global agricultural chain, contributing to reducing the GHG emissions, especially CH_4 in crop production, animal husbandry and deforestation.

Source: Vietnam News Agency (2022, September 23)

2-2 Demands of Expanding Irrigation Area in the LMB

All the MRC Member Countries have plans to expand irrigation areas to increase rice production and its exports, diversify food production, and improve their food security and rural poverty. However, there are differences in the speed of irrigation expansion among the countries. In the past 30 years, in Lao PDR and Cambodia, there has been low development of their irrigation sectors compared to Thailand and Viet Nam, which had been rapidly developed their irrigation infrastructures until the 2000s. Currently, the total developed irrigated area in the LMB is estimated at between 4.0 million ha and 5.0 million ha (MRC, 2018).

The share of the developed irrigated areas in the Member Countries is shown in Figure 1.

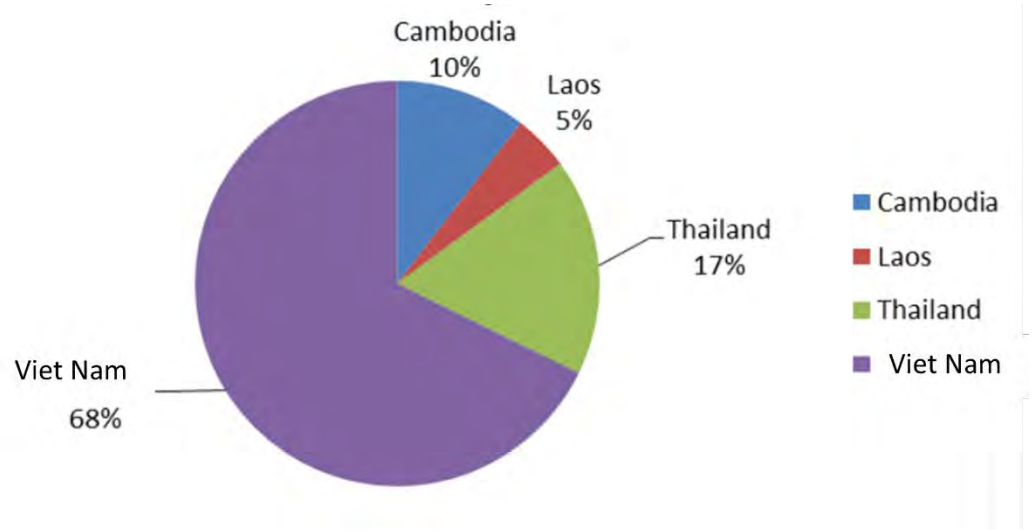

Figure 1. Share of developed irrigated areas in the Member Countries

Source: MRC, 2018

The total irrigation area in the LMB could nearly double in the long term, reaching up to 7 million ha. In these hypothetical plans, Lao PDR, Cambodia and Thailand would dramatically increase their developed area, whereas there would be very limited development in Viet Nam (MRC, 2018).

In the LMB, besides Viet Nam that has already vast developed irrigated area in the Mekong Delta, there is a strong demand for expanding irrigation area including the irrigation for rice production in paddy fields to produce more rice and ensure food security.

2-3 Rice Farming in Paddy Requires Much Water

Agriculture is the sector which uses the largest volume of water. Of the total volume of water use in the world, 4,010 km^3 per year, the water volume used in the agriculture sector is 2,881 km^3 per year. Of the total water volume used in the agricultural sector, 75% is used in Asia (FAO, 2022).

Further, irrigation is the largest water user in the LMB using 12% of the average annual flow (MRC, 2018).

The more efficient water use in agriculture is important particularly during the dry season to make the agriculture more sustainable and to avoid a future competitive water demand among sectors and countries in the LMB. In addition, in the case of pumping irrigation, saving water directly brings economic and environmental benefits to water users.

2-4 Why is the Intermittent Irrigation Useful for the Member Countries?

As written in the previous section, rice field in Asia is a big source of emission of CH_4 while rice field produces rice as a staple food for the people in Asia and provide public goods such as flood protection, groundwater recharge, and land slide prevention as well as ensuring food security. In addition, there is a high probability of further expansion of rice fields with irrigation.

Rapidly reducing CH_4 emissions from agriculture can achieve near-term gains in efforts in a decade for decisive action and is regarded as the single most effective strategy to keep the goal of limiting warming to 1.5˚C within reach while yielding co-benefits including improving agricultural productivity (Global Methane Pledge, n.d.).

On the other hand, the way to reduce CH_4 emissions should be sustainable, acceptable to farmers and have any incentives to introduce. Even if the way has significant positive effects of reducing CH_4 emissions from rice fields, a complicated way for the farmers is unlikely to be practical.

In addition to the issue of CH_4 emissions from the rice paddy fields, how to improve water use efficiency and increase water productivity is another important and urgent issue on the sustainability of rice farming in the LMB.

The Intermittent Irrigation has some advantages to solve these issues. The Intermittent Irrigation can be an irrigation technique that realizes at the same time reducing CH_4 emissions, increasing rice yield, and saving irrigation water and pumping cost with an applicable way for the farmers without loading them big burdens, which would make the agriculture in the LMB more sustainable.

3 METHODOLOGY OF THE INTERMITTENT IRRIGATION

3-1 Mechanisms of Soil CH_4 Emission

Water regimes before and during a rice cultivation period are known to be a major factor of CH_4 emission intensity (Ogle et al., 2019).

CH_4 is produced from labile organic C by microbes under strictly reductive soil conditions that is developed by Continuous Flooding. CH_4 is emitted mainly through rice plants during flooded periods. Drainage supplies oxygen (O_2) into the soil, thereby ceasing CH_4 production (Minamikawa, 2022) (Figure 2).

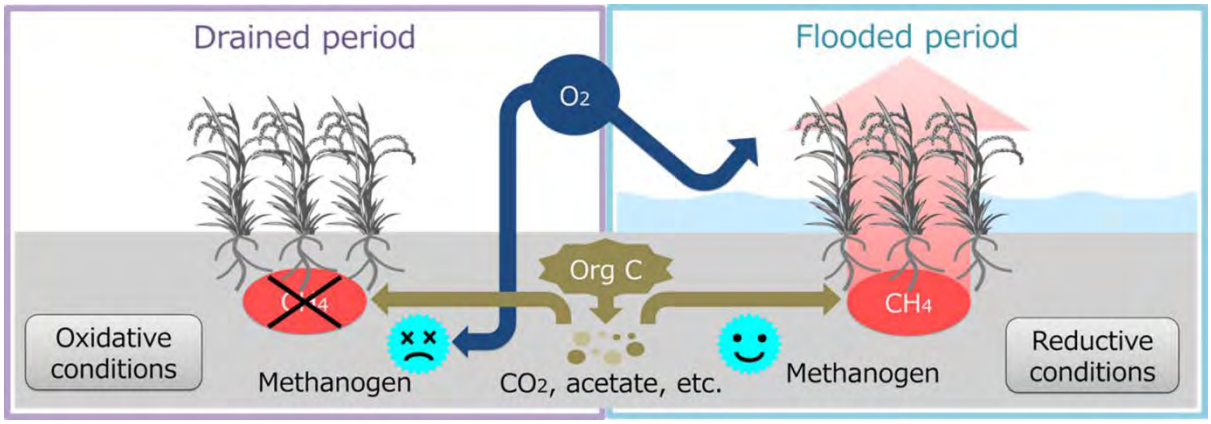

Figure 2. Mechanisms of soil CH_4 emission

Source: Minamikawa, 2022

3-2 Two Categories of Water Management Practices in Paddy

Water management practices in paddy can be classified into two categories, (i) Continuous Flooding and (ii) Non-continuous Flooding. The Continuous Flooding is very common and widely used in paddy in the MRC Member Countries. In the Continuous Flooding condition, excluding a short period to allow weed control, constant pond water is maintained in the field until the pre-harvest drainage (Gabriele et al., 2019).

Various water management practices and patterns are included in the Non-continuous Flooding such as water saturation, single drainage and Multiple Drainage. In this guidance, the difference in positive effects between on the Continuous Flooding and on the Non-continuous Flooding with the multiple drainage, i.e. Intermittent Irrigation, is highlighted.

The classification of the water management practices in paddy is shown in Figure 3.

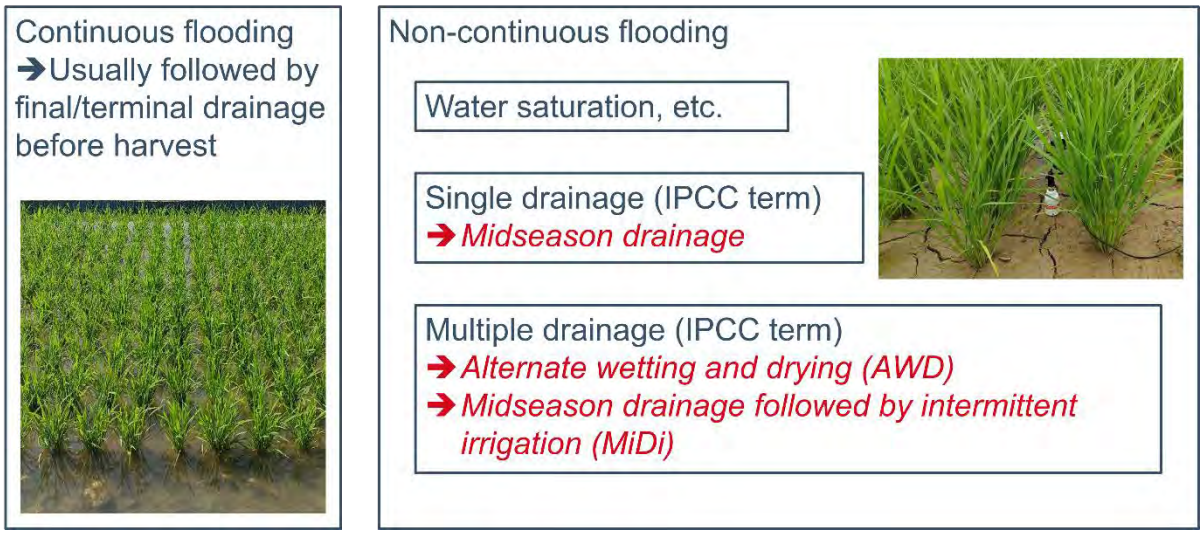

Figure 3. Classification of water management practices in paddy

Source: Minamikawa, 2022

3-3 What is the Intermittent Irrigation?

The Intermittent Irrigation is an irrigation technique for rice farming in paddy fields. The Intermittent Irrigation can be categorized as the non-flooding rice farming practice with the multiple drainage. In the Intermittent Irrigation practice, water supply to plots of the paddy fields (irrigation) and natural drainage from the plots are conducted over and over again during rice growing stages.

For the Intermittent Irrigation, some positive effects are known such as possibility of rice yield increase, reduction of CH_4 emissions from the paddy fields, and water saving.

It is important to note that there is no unique method of the Intermittent Irrigation because the best method of the Intermittent Irrigation should be different in each paddy area according to its conditions and state of irrigation and drainage, farming practices, and farmers' capabilities, and so on. The effects of the Intermittent Irrigation are also different in the methods to be applied and practiced by the farmers.

3-4 How to Implement the Intermittent Irrigation?

In this guidance, the following three types of the Intermittent Irrigation practices are introduced.

(a) Alternate Wetting and Drying (AWD)
(b) Farmers Simplified Alternate Wetting and Drying (FAWD)
(c) Midseason Drainage Followed by Intermittent Irrigation (MiDi)

3-4-1 Alternate Wetting and Drying (AWD)

What is the AWD?

The AWD is a water-saving technology that farmers can apply to reduce their irrigation water consumption in rice fields without decreasing its yield. In the AWD, irrigation water is applied

a few days after the disappearance of the ponded water. Hence, the field gets alternately flooded and non-flooded. The number of days of non-flooded soil between irrigations can vary from one to more than 10 days depending on the number of factors such as soil type, weather, and crop growth stage (IRRI, n.d.).

How to Implement the AWD?

A practical way to implement the AWD safely is by using a field water tube (pani pipe) to monitor the water depth on the field. After irrigation, the water depth will gradually decrease. When the water level has dropped to about 15 cm below the surface of the soil, irrigation should be applied to re-flood the field to a depth of about 5 cm. From one week before to a week after flowering, the field should be kept flooded, topping up to a depth of 5 cm as needed. After flowering, during grain filling and ripening, the water level can be allowed to drop again to 15 cm below the soil surface before re-irrigation (IRRI, n.d.).

Figure 4 shows an image of the water level control in the AWD.

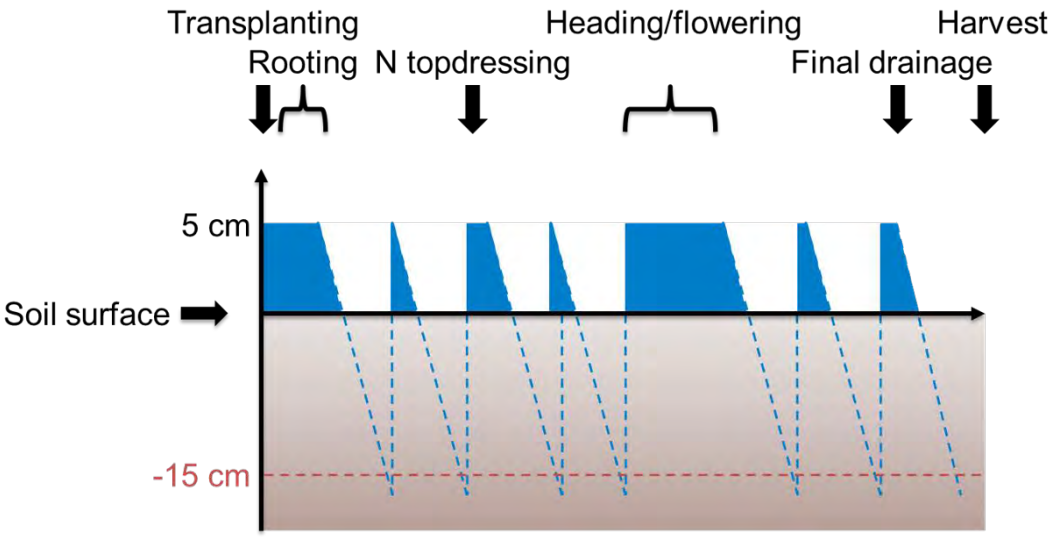

Figure 4. Image of the water level control in AWD
Source: Minamikawa, 2022

The AWD can be started a few weeks (12 weeks) after transplanting. When many weeds are present, the AWD should be postponed for 23 weeks to assist suppression of the weeds by the ponded water and improve the efficacy of herbicide. Local fertilizer recommendations for flooded rice can be used. Apply fertilizer nitrogen (N) preferably on the dry soil just before irrigation (IRRI, n.d.).

The Field Water Tube (Pani Pipe)

The field water tube can be made of 30 cm long plastic pipe or bamboo and should have a diameter of 10-15 cm so that the water table is easily visible, and it is easy to remove soil inside (Figure 5). Perforate the tube with many holes on all sides, so that water can flow readily in and out of the tube. Hammer the tube into the soil so that 15 cm protrudes above the soil surface. Take care not to penetrate through the bottom of the plow pan. Remove the soil from inside the tube so that the bottom of the tube is visible (IRRI, n.d.).

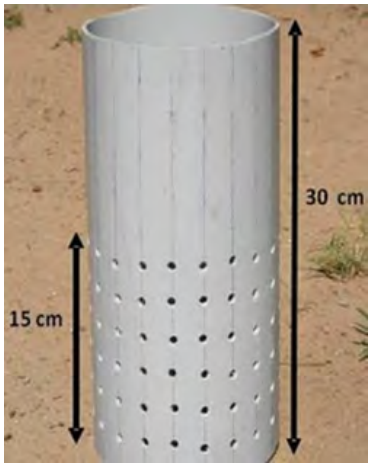

Figure 5. Field water tube (pani pipe)

Source: IRRI, n.d.

When the field is flooded, check that the water level inside the tube is the same as outside the tube (Figure 6). If it is not the same after a few hours, the holes will probably be blocked with compacted soil and the tube needs to be carefully re-installed. The tube should be placed in a readily accessible part of the field close to a bund, so it is easy to monitor the ponded water depth (Figure 7). The location should be representative of the average water depth in the field (i.e. it should not be in a high spot or a low spot) (IRRI, n.d.).

In the Figure 7, the water at 15 cm below the soil surface, which shows the time to irrigate the field again.

Figure 6. Field tube in flooded field

Source: IRRI, n.d.

Figure 7. Monitor the ponded water depth

Source: IRRI, n.d.

3-4-2 Farmers Simplified Alternate Wetting and Drying (FAWD)

While the AWD is known for its significant positive effects on saving water and reducing CH_4 emissions in paddy fields, there is a concern on the AWD that the strict control of water level in the paddy fields is a big burden for famers and is not an easy task.

In the Mekong Delta, experiments of the AWD were conducted by researchers of the IRRI in An Giang province, Viet Nam before 2010. Thereafter the AWD was introduced by the Department of Agriculture and Rural Development (DARD) in An Giang province. However, actually, farmers in An Giang province did not strictly apply the AWD practice, rather, made it simple by themselves due to difficulty of the strict water level control in their paddy fields (Taminato, 2016).

The farmers in An Giang province judged the timing of irrigation after drained water from the paddy fields based on their own experience by looking at and stepping on soil in the paddy plots.

In this guidance, the wording of the 'Farmers Simplified Alternative Wetting and Drying (FAWD)' shows the water control practice as such, being adjusted and conducted by the farmers as in An Giang province rather than the 'strict' AWD.

3-4-3 Midseason Drainage Followed by Intermittent Irrigation (MiDi)

The MiDi is a kind of multiple drainage practice as well as the AWD. The MiDi is a typical practice in Japan that has a long history for more than 150 years aiming at sound rice growth and yield increase. The MiDi features rice stage-dependent water management. (Minamikawa, 2022).

The MiDi is expected to have the following positive effects (Minamikawa, 2022):

(i) reducing toxic substances such as hydrogen sulfide (H_2S) and organic acids;
(ii) removing ineffective tillers with deliberate drought stress;
(iii) resistance to lodging;
(iv) promoting grain filling/C translocation with deliberate drought stress.

Figure 8 shows an image of the water level control in the MiDi.

In the MiDi, farmers repeat irrigation and drainage in paddy fields during specific certain stages of rice growing. During the transplanting stage including rooting stage, the water level in a paddy field is kept at 5 cm above the ground surface. After the transplanting stage, the water is drained for seven days for late tillering. After the seven days drainage, water is supplied up to 5 cm water level, and subsequently irrigation and drainage cycle that water supply up to 5 cm and three days drainage is repeated until heading/flowering stage. During the heading/flowering stage, the water level is kept at 5 cm. After the heading/flowering stage, the irrigation and drainage cycle that water supply up to 5 cm and three days drainage is repeated again until final drainage before harvest.

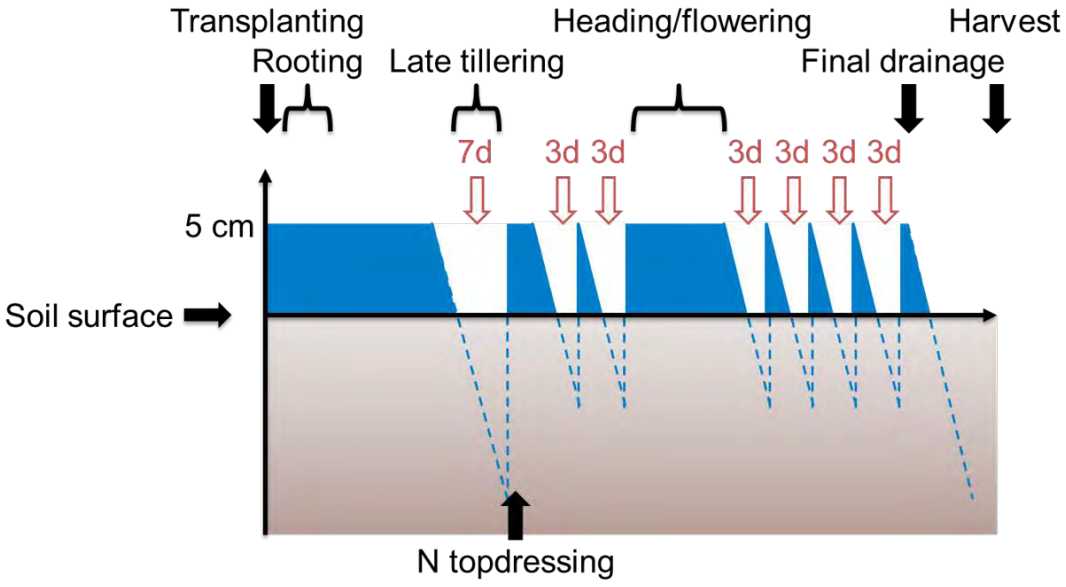

Figure 8. Image of the water level control in the MiDi
Source: Minamikawa, 2022

The MiDi is a water management practice that tries to improve the difficulty for the rice farmers to apply. The MiDi has potentials to realize the positive effects on increasing rice yields, saving water use, and reducing CH_4 emissions. On the other hand, the detailed method

of the intermittent irrigation after the midseason drainage needs to be adjusted and verified in each location according to the conditions such as weather and soil texture.

4 ADVANTAGES OF THE INTERMITTENT IRRIGATION

4-1 Possibility of Increase of Rice Yield

Uno et al. (2021) conducted an experiment in An Giang province, Viet Nam where full dike systems are prevailing in the Mekong Delta to evaluate the effects on the multiple drainage comparing with the Continuous Flooding on rice cultivation in paddy fields.

In this experiment, farmers were requested to follow instruction mentioned below for the Continuous Flooding and the multiple drainage through daily observations of the surface water levels. In the Continuous Flooding plots, the surface water level should be maintained between 0 and 10 cm above the soil surface, whereas in the multiple drainage plots the field should be irrigated when the water level naturally declined to 15 cm below the soil surface. In addition, the farmers were given room to adjust the depth threshold and timing of drainage in the multiple drainage plots according to their experience (e.g. maintaining flooded conditions for the N fertilizer topdressing) and the field drainage conditions (e.g. poor drainage due to rainfall and/or low altitude), that is, the farmers simplified AWD (Uno, 2021).

Uno et al. (2021) conducted field experiments at three remote sites in the province through six consecutive rice growing seasons with following ordinal local conventional agronomic practices other than the instructed water control in the paddy plots.

The multiple drainage was conducted with varying degrees of success at each site, except during heavy rainfall events. Rice yield was significantly ($P<0.05$) increased (by 22%) in the multiple drainage plots relative to the Continuous Flooding plots. A significant interaction between growing season and water management was also observed. The results indicate that appropriate implementation of the multiple drainage can increase rice yield in An Giang Province. Although any growth parameters were not measured in the study, it is assumed that the repeated non-severe drainage induced favorable soil conditions for rice growth at the tested sites. However, further study, especially on root growth, is necessary to elucidate the detailed mechanisms underlying the increase of rice yield by the multiple drainage in the regional context (Uno, 2021).

Especially for triple rice cropping systems with short fallow periods, as at the test sites, amelioration of strictly reductive soil conditions through the multiple drainage may have prevented lodging by inhibiting the production of substances harmful to rice, such as the H_2S and organic acids, and by enhancing root elongation (Minamikawa et al., 2019).

Uno and Shindo (2021) assessed rice yield difference between the Continuous Flooding and the FAWD in An Giang province, Viet Nam from spring in 2015 to spring in 2018. The test results show that the rice yield was 4.98 t/ha in the Continuous Flooding plots and 6.17 t/ha in the FAWD plots. The FAWD plots were higher than the Continuous Flooding plots by 1.19 t/ha. The results of test are shown in Figure 9, Figure 10 and Figure 11.

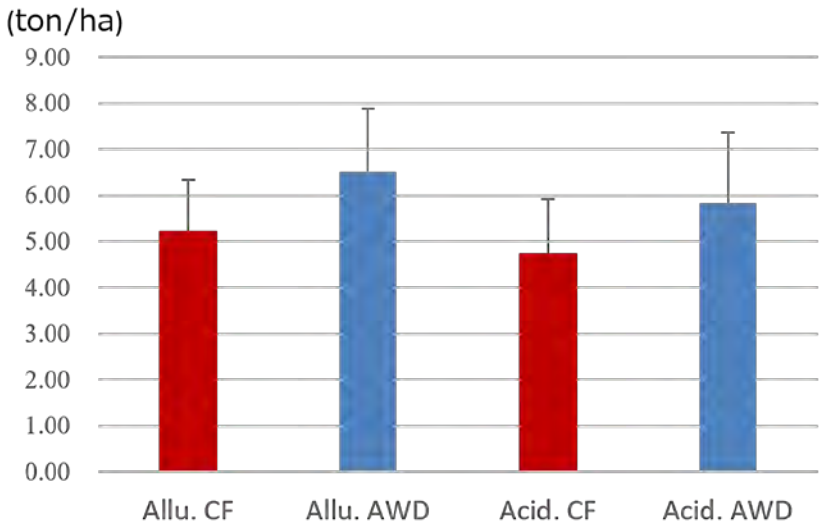

Figure 9. Rice yield of the Continuous Flooding and the FAWD
Source: Uno & Shindo, 2021

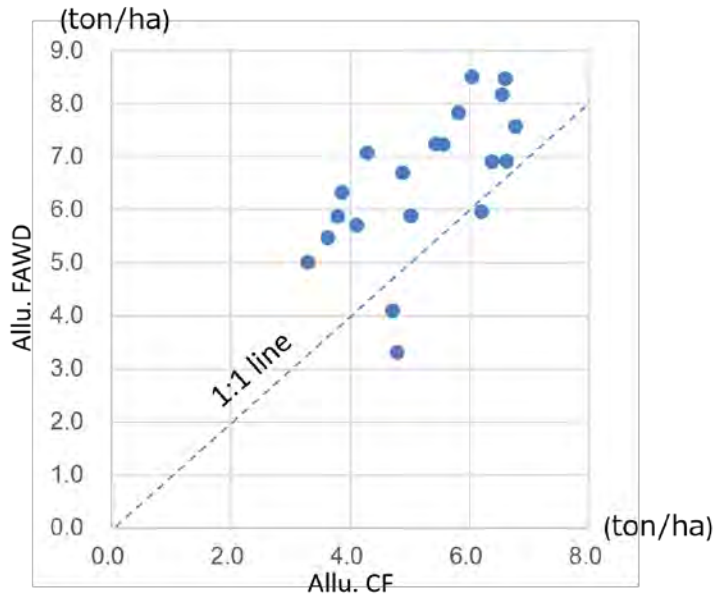

Figure 10. Rice yield of the Continuous Flooding and the FAWD on alluvial soil
Source: Uno, 2022

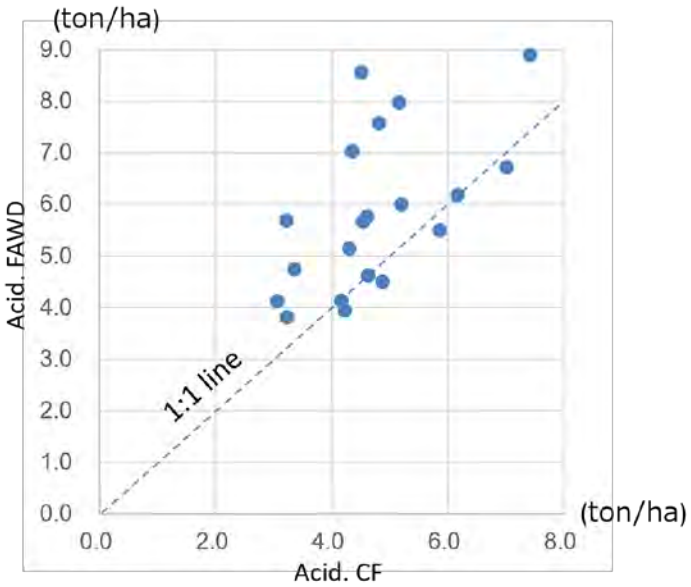

Figure 11. Rice yield of the Continuous Flooding and the FAWD on acid sulphate soil
Source: Uno, 2022

To assess whether the AWD and organic amendment can increase rice yield while mitigating CH_4 emission, Hoang et al. (2023) conducted experiments in a farmer's paddy field in Thua Thien Hue Province, Viet Nam, during five consecutive rice growing seasons in 20192021. The results showed that compared with the Continuous Flooding, the AWD significantly reduced CH_4 emission by 34%, increased N_2O by 46%, and increased grain yield by 4.4%. The AWD with the application of a commercially available organic fertilizer significantly increased the yield by 3.7% relative to without the organic fertilizer. Relative to the Continuous Flooding without the organic fertilizer, the AWD with the organic fertilizer significantly increased the yield. The integrated global warming potential of CH_4 and N_2O emissions was decreased by 33% and irrigation water use was reduced by 33% in the AWD plots relative to that in the Continuous Flooding plots. These results indicate that the AWD by itself has the potential to increase rice yield as well as reduce CH_4 emission, and the combination of the AWD with organic amendment would ensure yield increase.

Regarding straw management with the AWD which might affect to rice yield, Arai et al. (2021) studied effects of straw management to rice yield in the AWD study in the Mekong Delta. They prepared three straw treatments: all raw straw return, all straw-ash return, and no straw return to the paddy. For other field management, they adopted locally conventional methods. Results showed that the straw treatment effects on the rice yield were not significant.

It is to be noted as a risk of the Intermittent Irrigation that while numerous studies have shown that the AWD practice can reduce both GHG emissions and water use, the AWD can reduce rice yields if not implemented correctly. Carrijo et al. (2017) found that the AWD threshold had a major effect on yields and that yields could be maintained in most soils under Safe AWD in which soil water potential is >= -20 kPa or field water level does not drop below 15 cm from the soil surface. In contrast, Severe AWD resulted in yield losses in which soil water potential is < -20 kPa or field water level drops below 15 cm from the soil surface. The effects of the Intermittent Irrigation on the rice yields are different in some factors such as

the AWD threshold, duration and frequency, and nature of soil. Therefore, it is important to conduct a pilot testing in a plot in advance to seek the best way of the Intermittent Irrigation practice including the effects on the rice yield.

4-2 Reduction of CH_4 Emissions

The AWD was originally developed as a water saving technology without decreasing rice yield (IRRI, n.d.).

In addition to water saving, the AWD has a potential to significantly reduce CH_4 emissions without making sacrifice of the rice yield.

Leon et al. (2020) said that the AWD allowed the farmers in An Giang Province, Viet Nam to reduce life cycle GHG emissions without decreasing the yields significantly and with lower use of fertilizers (nitrogen and phosphate) and seeds (Figure 12).

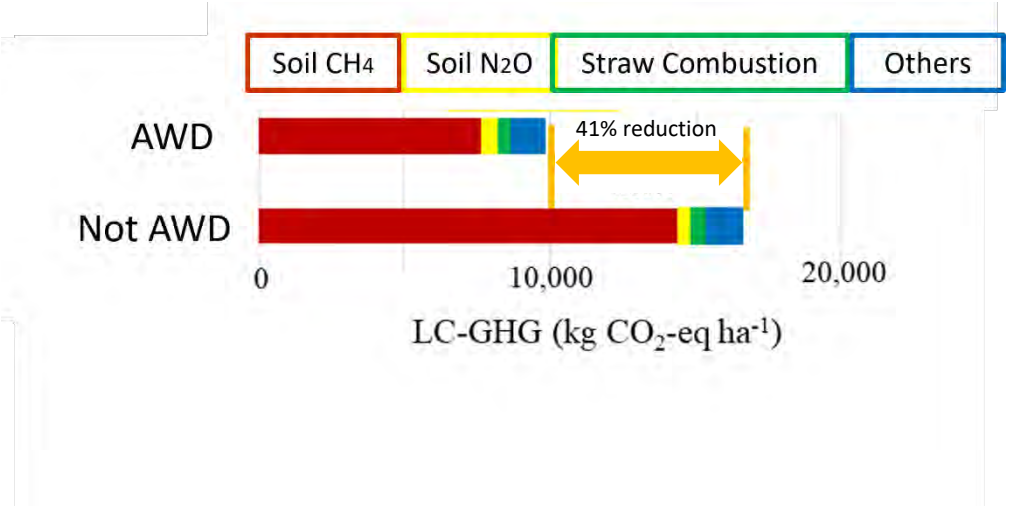

Figure 12. GHG was reduced by 41% in the life cycle due to implementation of the AWD
Source: Leon, et al. 2020

Taminato et al. (2016) performed rice cultivation experiments in the Mekong Delta by using two types of the AWD: one is recommended by the IRRI and the other is customarily used by farmers, that is, the FAWD.

Both the AWD and the FAWD successfully reduced year-round CH_4 emissions without decreasing rice yields. Compared with the Continuous Flooding, the AWD and the FAWD reduced the total CH_4 emissions by 49%-74% and 21%-48%, respectively. In the dry season, there was a strong correlation between total CH_4 emissions and the number of cumulative days on which water levels were below the paddy field soil surface (Taminato, 2016).

Uno and Shindo (2021) also assessed the difference in emissions of CH_4 between the Continuous Flooding and the FAWD in An Giang province, Viet Nam from spring in 2015 to spring in 2018. The test results show that CH_4 emission in the Continuous Flooding plots was 4.55 t CO_2/ha and 2.72 t CO_2/ha in the FAWD plots on average per one rice crop season. The emissions of CH_4 on average were reduced about 40% in the FAWD plots than in the Continuous Flooding plots. Looking at each soil type, the emissions of CH_4 on average were

reduced 23.8% (0.98 t CO_2/ha per one crop season) in the FAWD plots than in the Continuous Flooding plots for alluvial soil, and 55.4% (2.85 t CO_2/ha per one crop season) for acid sulphate soil. The results of test are shown in Figure 13 and Figure 14.

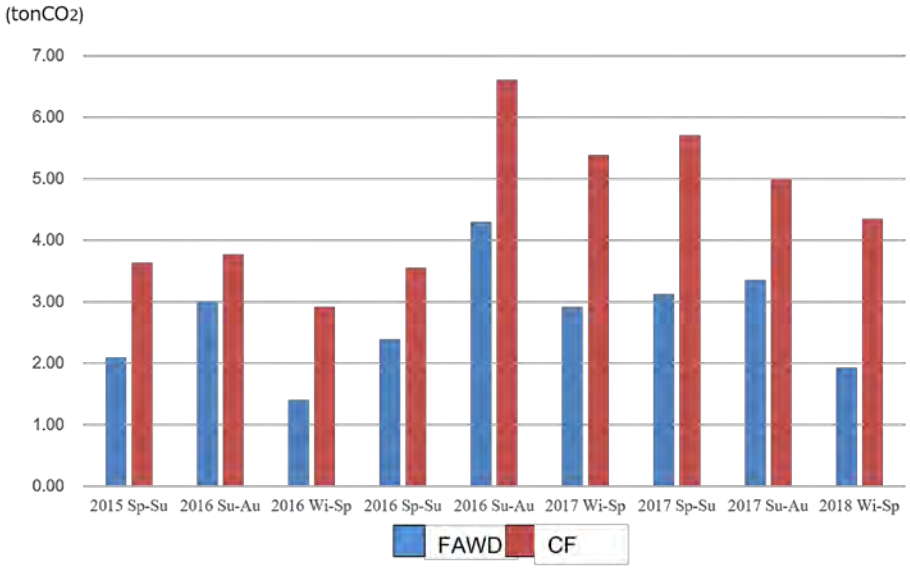

Figure 13. CH_4 emissions on the FAWD plots and the Continuous Flooding plots in each rice crop season

Source: Uno, 2022

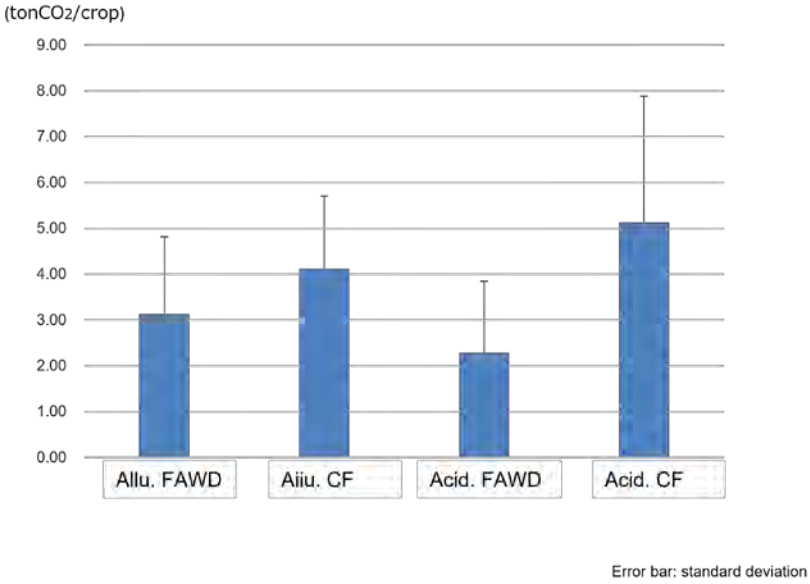

Figure 14. CH_4 emissions on the FAWD plots and the Continuous Flooding plots in each soil type
Source: Uno, 2022

It is known that there is a trade-off between the emission of CH_4 and N_2O in the Intermittent Irrigation (Cai et al., 1997; Yue et al., 2005; Zou et al., 2005).

Yang et al. (2012) indicate that when the Intermittent Irrigation is conducted, the emission of N_2O is promoted by the nitrifying bacteria due to increasing of oxygen concentration in soil than the plots of the CF.

On the other hand, Uno et al. (2021) found in a study conducted in An Giang province in Viet Nam that seasonal total N_2O emissions were not affected by either growing season or water management, and the trade-off with CH_4 emissions was not always consistent.

It is desirable to collect and analyze data of the N_2O emissions as well as CH_4 emissions when applying the Intermittent Irrigation considering the trade-off between the reduction and emissions of the two GHGs.

4-3 Saving Irrigation Water and Pumping Cost

Uno and Shindo (2021) analyzed reduction of pumping cost and frequency of use of pump on the FAWD plots compared with the Continuous Flooding plots in An Giang province, Viet Nam from spring in 2015 to spring in 2018. The results in the FAWD plots show the both of less pumping cost and less frequency of the use of pump than those in the Continuous Flooding plots, which indicates a possibility of saving irrigation water and pumping operations (Figure 15). The pumping cost was VND 1,013,000/ha per one crop season in the Continuous Flooding plots and VND 708,000/ha per one crop season in the FAWD plots. The FAWD plots were lower than the Continuous Flooding plots by VND 305,000/ha.

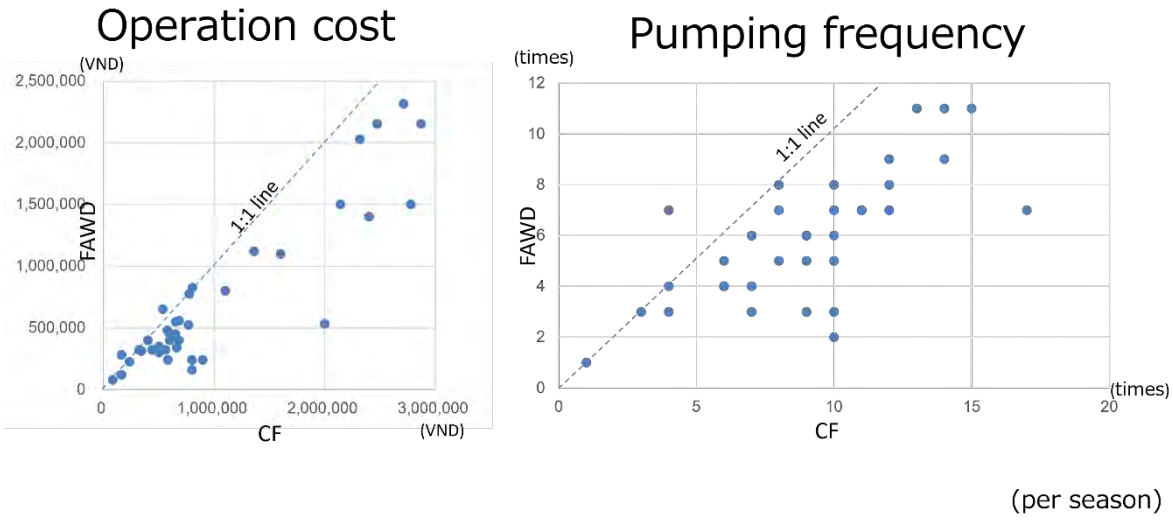

Figure 15. Pumping cost and frequency in the FAWD plots and in the CF plots
Source: Uno, 2022

4-4 Estimated Monetary Value by Applying the Intermittent Irrigation

Uno (2019; 2022) tried a preliminary estimation on monetary value of benefits from the FAWD implementation based on the results of the test conducted in An Giang province, Viet Nam from spring in 2015 to spring in 2018. The estimation is shown in Box 2.

Box 2. An estimation on monetary value of benefits from the FAWD implementation in An Giang province, Viet Nam

From the results of the test in An Giang province, Viet Nam, the three positive effects of the rice yield increase, CH_4 reduction and the saving pumping cost from the FAWD

implementation can be estimated in monetary value as follows (per ha, per year and double cropping per year):

(i) Rice yield increase: 2.38 t * VND 5,500,000/ton (unit price) = VND 13,000,000
(ii) CH_4 reduction: 3.82 t/CO_2 * VND 230,000/tonCO_2 (unit price) = VND 900,000
(iii) Saving pumping costs: VND 600,000

Therefore, total present value in case that the FAWD is implemented for 10 years would be the following (calculated with 6% social discount rate).

(900,000 + 13,000,000 + 600,000) $\times \sum_{k=1}^{10}(1-0.06)^k \cong$ VND 100,000,000/ha

Source: Uno (2019; 2022)

In Vietnam, an analysis conducted by the IRRI shows that if the AWD is applied consistently on about 1.9 million ha under paddy, it can result in net profits estimated at USD 2.3 billion per year while reducing the GHG emissions by 10.97 million tCO_2 e per year by 2030 (with a total investment outlay of about USD 3.1 billion by 2030). On a 'per ha per year' basis, the application of the AWD results in an average net profit of USD 1,211 and the GHG emission reduction of 5.8 tCO_2e, based on results from Vietnam Sustainable Agricultural Transformation Project and the Agriculture Competitiveness Project (Shrivastava et al., 2022).

5 CONSTRAINTS AND REQUIREMENTS TO APPLY THE INTERMITTENT IRRIGATION IN THE MEMBER COUNTRIES

As shown in the previous section, applying the Intermittent Irrigation with multiple drainage for rice production in the Member Countries can bring not only for improvement of rice productivity but also more benefits as a measure of climate change mitigation.

However, applying the Intermittent Irrigation with multiple drainage requires farmers to convert from ordinary and accustomed rice production practices with the Continuous Flooding. While the Intermittent Irrigation will bring the aforementioned benefits, it will inflict additional burden on the irrigation water management on the farmers.

Among some Intermittent Irrigation practices, the MiDi is the one that is being designed and verified in order to minimize the trade-offs between the benefits and farmers' burden on the field level water management.

In order to disseminate and facilitate widely applying the Intermittent Irrigation in the Member Countries, effective field level water management on the Intermittent Irrigation and saving its labor force for the water management are important keys as well as a strong incentive to increase of the rice productivity to the farmers.

Investments are needed to improve existing canals and pumping facilities to enable controlled water management. These efforts must be backed up by enhanced training and an awareness campaign to encourage better water management behavior (Nelson, 2022).

Some advanced water management technologies and policy measures that realize at once improvement of the rice productivity and effective implementation of the Intermittent Irrigation are shown in this section.

5-1 Separate Canal for Irrigation and Drainage

Under the Continuous Flooding rice farming, development of drainage canals is not necessarily required because the paddy fields are always kept flooded. Thus, it is common that irrigation (water supply) and drainage in a paddy plot are done through a same canal not separating the irrigation and the drainage functions (Figure 16).

However, it is crucial for the Intermittent Irrigation to ensure the drainage functions in the paddy fields since the irrigation and the drainage are done repeatedly based on crop calendar. Hence, it is required to separate the functions of canals to the irrigation and the drainage functions respectively so that the farmers can irrigate and drain water from the paddy fields freely and timely.

In addition, water availability determines the suitability of the Intermittent Irrigation. There are hierarchical constraints on the adoption of the Intermittent Irrigation by farmers in terms of water use. The irrigated rice ecotype is more suitable to the Intermittent Irrigation than is the rainfed rice ecotype due to the high availability of water needed (Minamikawa et al., 2019).

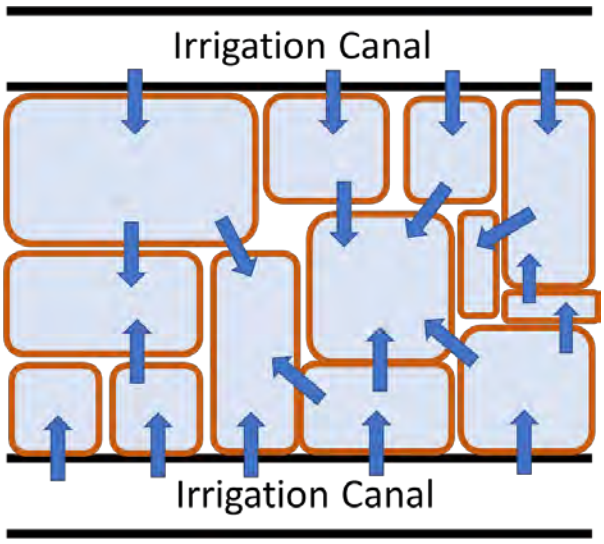

Figure 16. Continuous Flooding irrigation

5-2 Land Consolidation with Land Leveling

Leveling plots of paddy fields is important for efficiently conducting the Intermittent Irrigation by supplying water to and draining water from the plots smoothly and timely. Land consolidation at once with aligning and leveling the plots in the paddy fields and with developing irrigation canals and drainage canals enables the implementation of the Intermittent Irrigation easier and to significantly improve rice productivity (Figure 17).

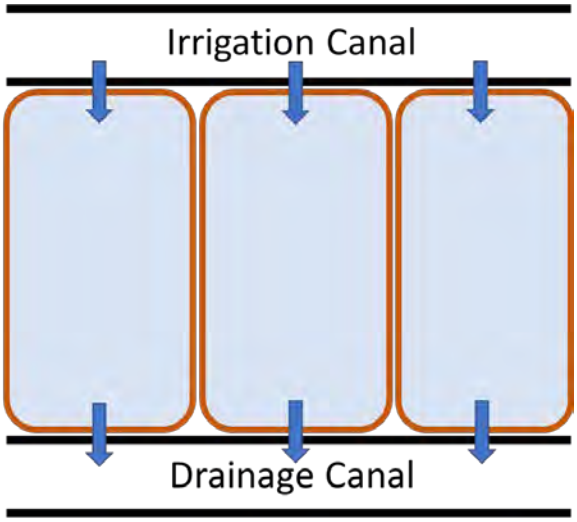

Figure 17. Land consolidation

5-3 Automatic Irrigation and Drainage with Information and Communication Technology

In Japan, the Irrigation technologies with the Information and Communication Technology (ICT) have been developed, which supply and drain water to and from plots in paddy fields through remote control of small gates. The technologies of automatic water control in the paddy fields with measuring water level by sensors are also practically used (Figure 18).

To control water supply, drainage and water level in the plots of the paddy fields for the Intermittent Irrigation with such advanced technologies seems to be effective for reducing burden of the farmers on the field level water management and for amplifying the positive effects of the Intermittent Irrigation.

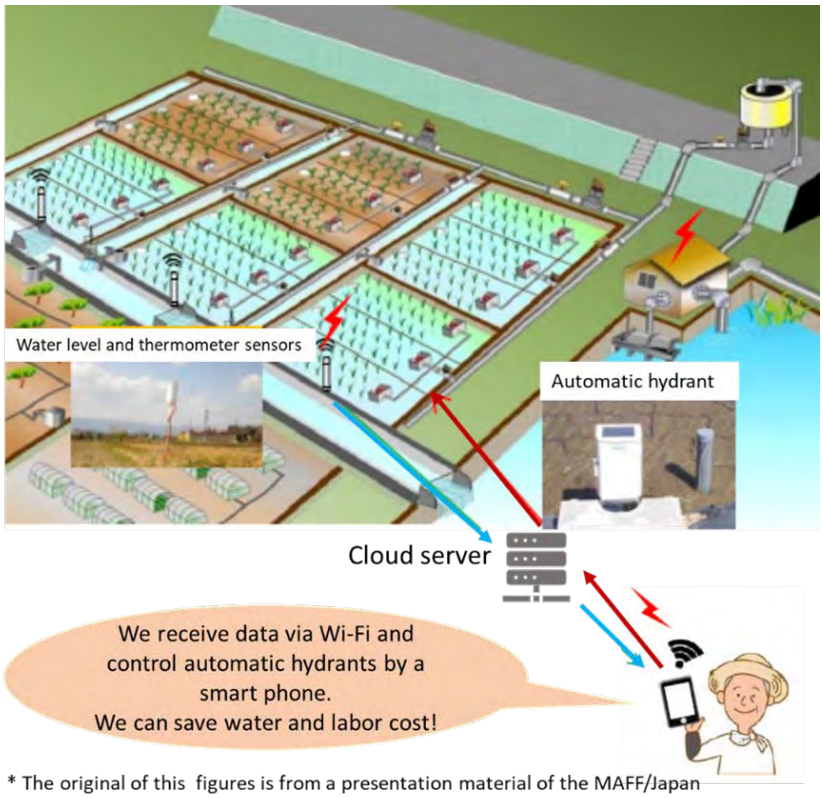

Figure 18. Automatic irrigation and drainage technology

Source: MRC, 2022

Pilots conducted in Vietnam using the internet of things (IoT)—which includes water sensors to help farmers better decide on the optimal amount of water to apply—showed a reduction in water use by up to 42% compared to manual flooding of rice fields, cutting production costs by up to 22%, and increasing rice yield by 24% (Choudhary et al., 2020).

These smart irrigation systems can reduce the GHG emissions by up to 60%-70% compared to the manual system of irrigation (equivalent to 4–6 tCO_2e per ha per crop season). The IoT-based systems integrate laser sensors for precise water level measurement for automation of the AWD technique for different sizes of fields. The use of such advanced technologies is upgradable by utilizing various sensors, wireless links, and internet infrastructure due to the increasing availability and decreasing cost of these technologies (Shrivastava et al., 2022).

5-4 Cost Incentive

Switching to greener technologies may generate additional costs, and farmers must bear start-up investment costs while facing low margins, high transaction costs, and uncertain returns (Shrivastava et al., 2022).

Actually, it is expected that the Intermittent Irrigation significantly reduce the emissions of CH_4 from paddy fields whereas the Intermittent Irrigation requires farmers to put the additional labor on the water management during their rice cultivation.

In the future, to consider any cost incentive to the practitioners of the Intermittent Irrigation such as introducing a credit mechanism and access to international climate funding is important so that the positive effects of the Intermittent Irrigation on the reduction of CH_4 emissions are properly evaluated and accounted to the GHG inventory, and the reduction of CH_4 emissions can be further promoted by disseminating the Intermittent Irrigation.

A recent analysis of potential funding found that there were four potential private donors (all nongovernmental organizations), and about 33 international funding sources, including multilateral development banks, international agencies and institutions, and bilateral sources (World Bank, 2021).

The potential role of carbon market financing, which needs to be explored for low-carbon rice, would also benefit from strong private sector participation. This is critical to incentivize the millions of farmers and agribusiness players to participate in sustainable low-carbon practices. The value of the global carbon market hit nearly USD 280 billion in 2020, but agriculture-related emissions' projects account for only 1% of all carbon credits issued (Shrivastava et al., 2022).

Nelson et al. (2022) said that Vietnam's participation in the methane reduction pledge represents an opportunity to tap into international climate funding. These funds could channel resources into green agricultural development projects in rural regions and secure funds for low-income farming populations heavily threatened by climate change.

In Mach 2023, in Japan, '[Extending duration of Midseason Drainage in Rice Paddy]' has been approved as one of target activities whose effects on reducing the GHG emissions can be traded.

The outline of this carbon credit scheme is shown in Box 3.

Box 3. Outline of carbon credit scheme for extending duration of Midseason Drainage in rice paddy in Japan

On 1 March 2023, the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF) announced that 'Extending duration of Midseason Drainage in Rice Paddy' was approved as a new methodology on J-Credit Scheme in Japan (MAFF, 2023).

The J-Credit Scheme is designed to certify the amount of the GHG emissions reduced and removed by sinks within Japan (J-Credit Scheme, n.d.).

For example, if one registers a project and gets approval of the J-Credit accreditation based on the methodology stipulated by the Japanese government, one can sell to buyers such as big companies the carbon credit (J-Credit) that is a difference on the amount of reduction of the GHG emissions between before and after taking the measures (Japan Food Industry News, 2023).

Quoting an average unit price for the J-Credit on forests that is already implemented in Japan, an estimated J-Credit selling price of the 'Extending duration of Midseason Drainage in Rice Paddy' is a range of about JPY 1,000-3,600/10a (Japan Food Industry News, 2023).

The CH_4 accounts for more than 40% of the total GHG emissions from agriculture, forestry and fisheries industries of Japan. Of which more than half is coming from rice cultivation in paddy fields (Japan Food Industry News, 2023).

In addition to visualization of reduction of the GHG emissions by farmers, foresters and fishers, it is expected that the J-Credit Scheme is utilized in agriculture, forestry and fisheries industries of Japan through selling the J-Credit (MAFF, 2023).

An image of this J-Credit Scheme is shown in Figure 19.

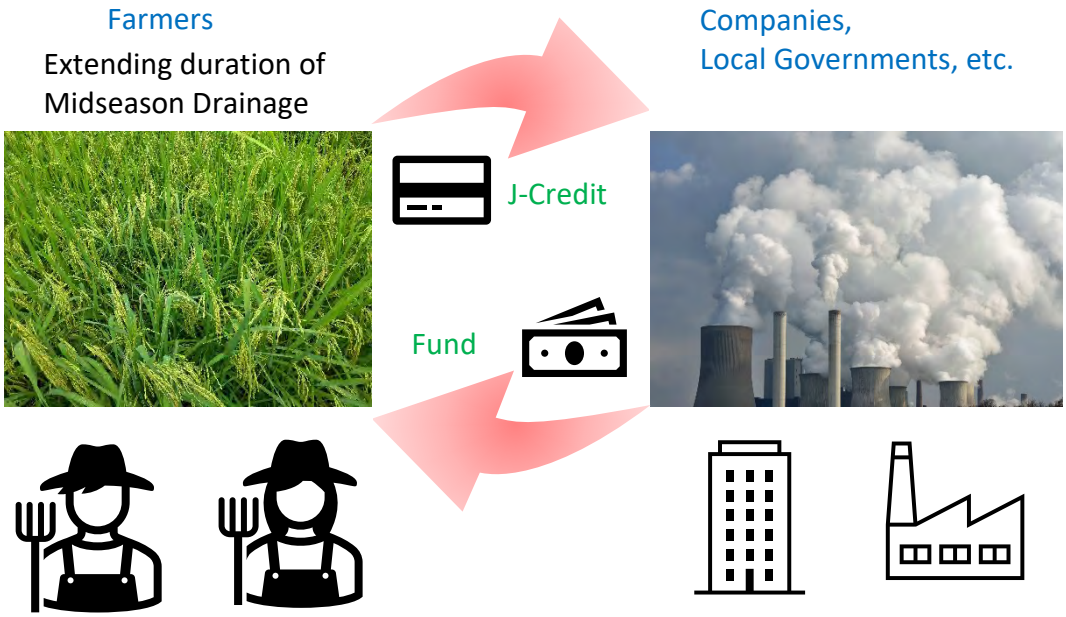

Figure 19. J-Credit Scheme

On 11 October 2023, Tokyo Stock Exchange opened its carbon credit market. Companies and local governments can sell and buy the J-Credit in this carbon credit market. Tokyo Stock Exchange aims to promote decarbonization in companies and local governments by giving economic incentives (Jiji Press Ltd., 2023).

After the approval of the '[Extending duration of Midseason Drainage in Rice Paddy]' in Japan as one of the target activities for the J-Credit, some new business models using this J-Credit scheme are being developed and considered in private sector.

An example of the business models is shown in Figure 19.

The partner farmers in this scheme will conduct the '[Extending duration of Midseason Drainage in Rice Paddy]' in their rice farming. The NTT Communications Corporation provides

the partner farmers with IoT Application to collect automatically data and evidence on conducting the '[Extending duration of Midseason Drainage in Rice Paddy]'. The NTT Communications Corporation will apply for the J-Credit based on the collected data and evidence through the IoT Application. The NTT Communications Corporation will sell the registered J-Credit to other companies. On the other hand, the Yanmar Marche Corporation will have contract farming with the partner farmers with farming support. The Yanmar Marche Corporation will sell the cultivated rice to consumers as environment-friendly rice with added value (Yanmar Marche & NTT Communication, 2023).

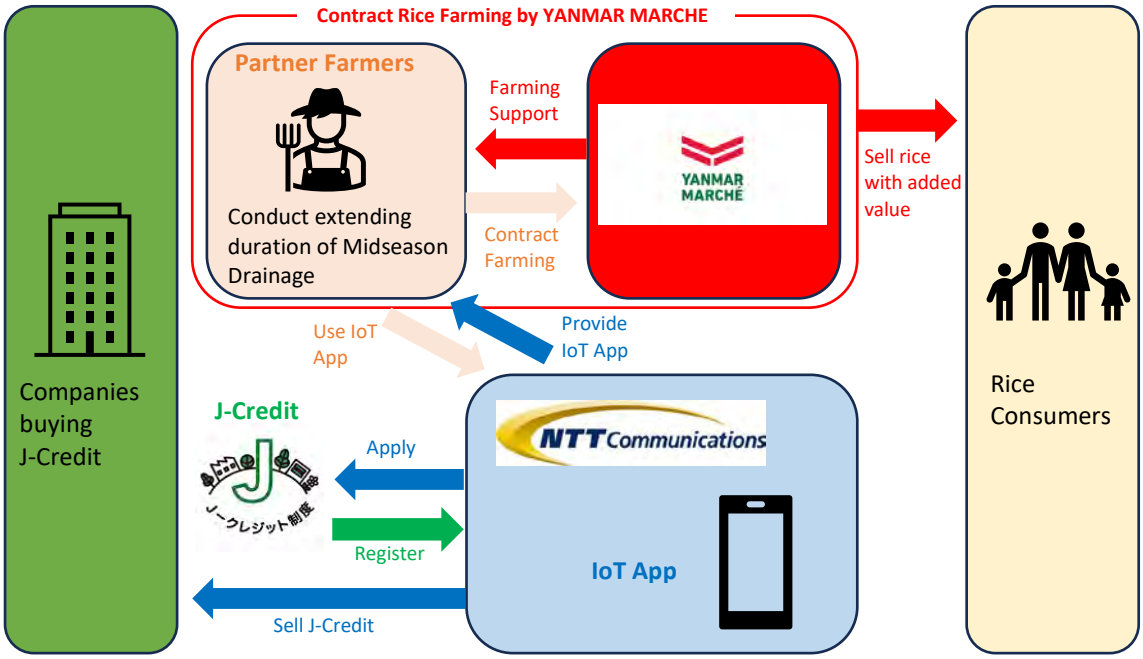

Figure 20. A Business Model Using J-Credit Scheme

Source: Yanmar Marche & NTT Communication, 2023

In Lao PDR, the government started working together with its development partners to develop carbon markets in September 2023 (Vientiane Times, 2023). The outline of the launched carbon market programme is shown in Box 4.

Box 4. Outline of Carbon Market Programme Launched in Lao PDR

The Ministry of Natural Resources and Environment of Lao PDR launched in September 2023 the Programme for Open and Sustainable Carbon Markets in Laos with Australia's Department for Foreign Affairs and Trade.

The programme will be implemented from 2023-2026, in partnership with the Government of Australia and the Global Green Growth Institute, with the aim of raising the role of carbon markets and credits in Laos' climate and development agenda. Through the programme, the government will put in place the policy, regulatory and institutional framework required to boost and properly managing the country's market for carbon credit trading. This will improve the regulatory environment for carbon projects, increase institutional and procedural clarity, reduce carbon project review and approval processing

times, and stimulate market activity. As part of this, the project will also build human and institutional capacity to support the development of a carbon market.

One of the main objectives of the programme is to establish a cross sectoral legal and policy framework that can facilitate the international trading of high-quality greenhouse gas emission reduction outcomes and attract climate financing to Laos.

With the rapid growth in carbon markets, the development of policy frameworks and regulations will enable Laos to capitalize on the benefits provided by international carbon markets, while accelerating climate action.

Source: Vientiane Times, 2023

In addition, in Lao PDR, the Lao government started a feasibility study on the Intermittent Irrigation in collaboration with private sector in order to evaluate the best techniques of the Intermittent Irrigation and ways to reduce methane emissions as well as to create an investment model between the government and the private sector. The Box 5 gives an outline of this feasibility study.

Box 5. Outline of Feasibility Study on Intermittent Irrigation launched in Lao PDR

The Department of Agriculture of the Ministry of Agriculture and Forestry of Lao PDR is partnering with Rice Farming Initiative Sole Co., Ltd. in a feasibility study on the AWD rice planting methodology and carbon generation in Savannakhet, Khammuan, Saravan and Champassak provinces.

The study will evaluate the best techniques for increasing the quantity and yields of rice planted using the AWD method. It will also evaluate ways to reduce methane emissions during rice cultivation, as well as carbon generation, while also looking at ways to foster bilateral cooperation in the development of agriculture to create an investment model between the government and private sector. If the results of the study are successful and accepted, Rice Farming Initiative Sole Co., Ltd. will set up a project to introduce the AWD system.

It is envisaged that this will save water, reduce methane emissions, and support the goals of the Ministry of Agriculture and Forestry to boost crop yields for food security, domestic sale and export, and poverty reduction.

Source: Vientiane Times, 2023

5-5 Consideration for Rice-fish System in the LMB

Capture fisheries production in the LMB is higher than anywhere in the world. Under the 2015 habit-approach, equal proportions of fish production (45%) derived from river-floodplain habitats in the major flood zone (moderate-high yield over a moderate area) and from rice

fields and associated habitats in the rain-fed zone (low-moderate yield over a very large area), with a minor contribution (about 10%) from reservoirs and other large permanent waterbodies outside the major flood and rain-fed zones. Capture fisheries are an important source of protein and income for those living in the LMB (MRC, 2019).

Total capture fisheries production in the LMB from the early 1990s to 2015 is shown in Figure 21.

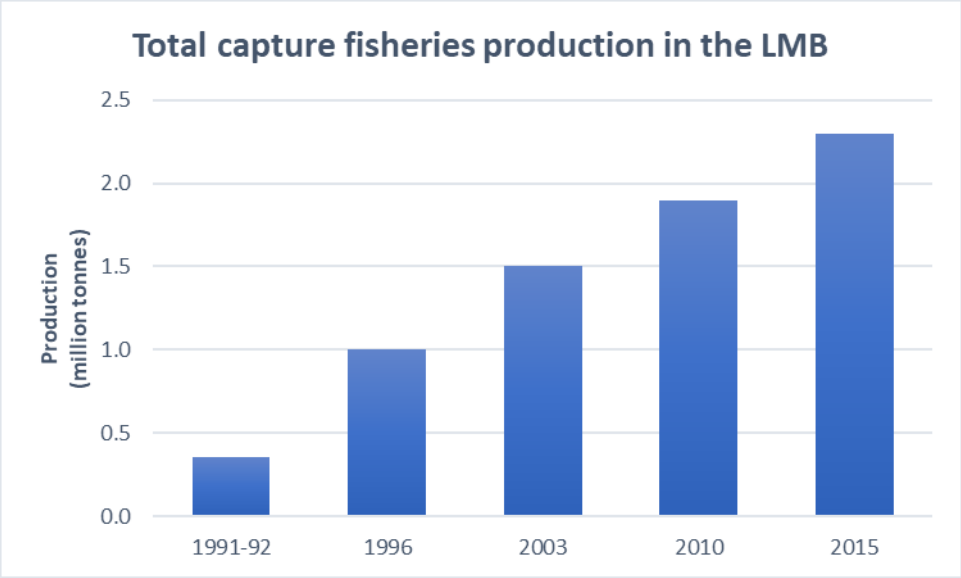

Figure 21. Total capture fisheries production in the LMB from the early 1990s to 2015

Source: MRC (2019)

Fish can be deliberately stocked or can enter rice fields naturally from surrounding water ways. The Rice-fish system is one of the multifunctionalities of rice farming in paddy fields in the LMB.

The Intermittent Irrigation is a technique that repeats irrigation and drainage in paddy fields. When considering applying the Intermittent Irrigation and if the capture fisheries are being done in the paddy fields of target area, there is a need to survey on potential negative effects for introducing the Intermittent Irrigation to the rice-fish system.

6 CONSIDERING GENDER APPROACHES IN THE INTERMITTENT IRRIGATION

The water level control in paddy plots is critical in the implementation of the Intermittent Irrigation. The measures easier to apply for farmers like the MiDi are being developed so that the operation on opening and closing the intake outlets in paddy plots cannot be much burden for the farmers. It is capable that the farmers operate remotely or automatically the opening and closing the intake outlets if an automatic irrigation and drainage system is introduced.

In the water level control in the paddy plots, removing the burden of the farmers including women as much as possible is a key point. In addition, we should consider how to tell the farmers including women the benefits of the Intermittent Irrigation in an easy-understandable way and how to ensure duly the benefits to women. These would enhance the positive effects on the Intermittent Irrigation and contribute to the sustainability of its implementation.

Integrating gender-sensitive approaches to irrigation technology dissemination can facilitate wider adoption of these technologies, leading to improved agricultural livelihoods, improved food and nutrition security, increased climate resilience, and women's empowerment (Bryan, E., & Didi, E. H., 2019).

The followings show some activities on the Intermittent Irrigation in which the roles are to be shared with women.

- Participate in community meetings such as planning and practice method of Intermittent Irrigation, water delivery rules, and use and allocation of carbon credit;
- Check water levels and soil conditions on paddy plots to know appropriate timing of water supply to the plots;
- Open and close outlets in paddy plots to withdraw and drain water to and from the plots;
- Record the Intermittent Irrigation practice to apply for the carbon credit;
- Operate and maintain automatic irrigation and drainage system if it is introduced;
- Provide feedback on the Intermittent Irrigation practice to improve the method of the Intermittent Irrigation and irrigation and drainage infrastructures.

7 RECOMMENDATIONS

This guidance explains the basic methodology and the effects of the Intermittent Irrigation based on the results of research projects conducted in the LMB.

Multiple positive effects are expected on the Intermittent Irrigation. In particular, the effects on the reduction of CH_4 emissions by implementing the Intermittent Irrigation are verified in a number of research projects, which is a field in which the rice paddy farming can contribute to tackling with the climate change issues as a way of the climate change mitigation.

On the other hand, implementing the Intermittent Irrigation could bring to farmers the additional labor on the water level control in their plots of the paddy fields. Any incentive to the farmers is crucial to introducing the Intermittent Irrigation. As the intensives to the farmers, the following could be considered: (i) rice yield increase; (ii) reduction of irrigation pumping cost (in case of pumping irrigation); (iii) development or upgrade of irrigation and drainage facilities with separating irrigation and drainage functions; (iv) development of automatic (or labor-saving) irrigation and drainage system; and (v) direct payment to the farmers for the reduction of CH_4 emissions.

A funding source is required for developing or upgrading the irrigation and drainage facilities and for direct payment to the farmers. As the funding source, measures such as international or domestic carbon credit mechanism and access to the international climate funds could be options, which needs to be considered in the medium- and long-term perspectives. There is a need to carefully watch international discussions and trends in terms of climate change adaptation and mitigation measures including carbon pricing.

The Intermittent Irrigation is a promising irrigation technique that could materialize a contribution to the climate change mitigation from agriculture sector through the rice paddy farming, modernization of agriculture, improvement of productivity, and efficient agricultural water use (increase of water productivity) by ensuring enabling environment of the Intermittent Irrigation in particular, modernizing irrigation and drainage facilities.

The effects and methodologies of the Intermittent Irrigation are not unique and are different in each area according to agricultural practices, weather conditions, soil conditions, status of development levels of irrigation and drainage facilities, and so on. Particularly, for the effects of the Intermittent Irrigation, it is necessary to measure, evaluate and verify the effects in each area where the Intermittent Irrigation is applied.

In that sense, this guidance is a living document and to be revised and updated referring to and incorporating the latest verification results of the effects and lessons learned from pilot projects of the Intermittent Irrigation applied in the LMB.

In order to promote introducing and disseminating the Intermittent Irrigation in the LMB, it is recommended to consider the following:

(a) Develop methodology and practice of the Intermittent Irrigation that is easy to apply and as less burden as possible for the farmers taking the gender approaches into consideration;
(b) Verify quantitatively the effects on the Intermittent Irrigation;

(c) Develop or modernize irrigation and drainage facilities that enable to implement the Intermittent Irrigation;
(d) Ensure access to funding sources to modernize the irrigation and drainage facilities and give incentives to the farmers.

It is expected that the area of the rice paddy farming that is more sustainable, highly productive and with less the GHG emissions increase in the Member Countries through introducing the Intermittent Irrigation with modernization of the irrigation and drainage facilities.

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