Greenhouse gas mitigation by alternate wetting and drying water management in irrigated rice paddies in Southeast Asia

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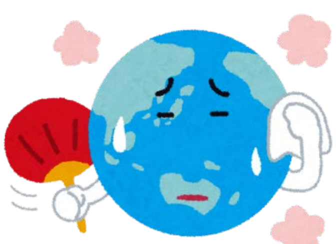
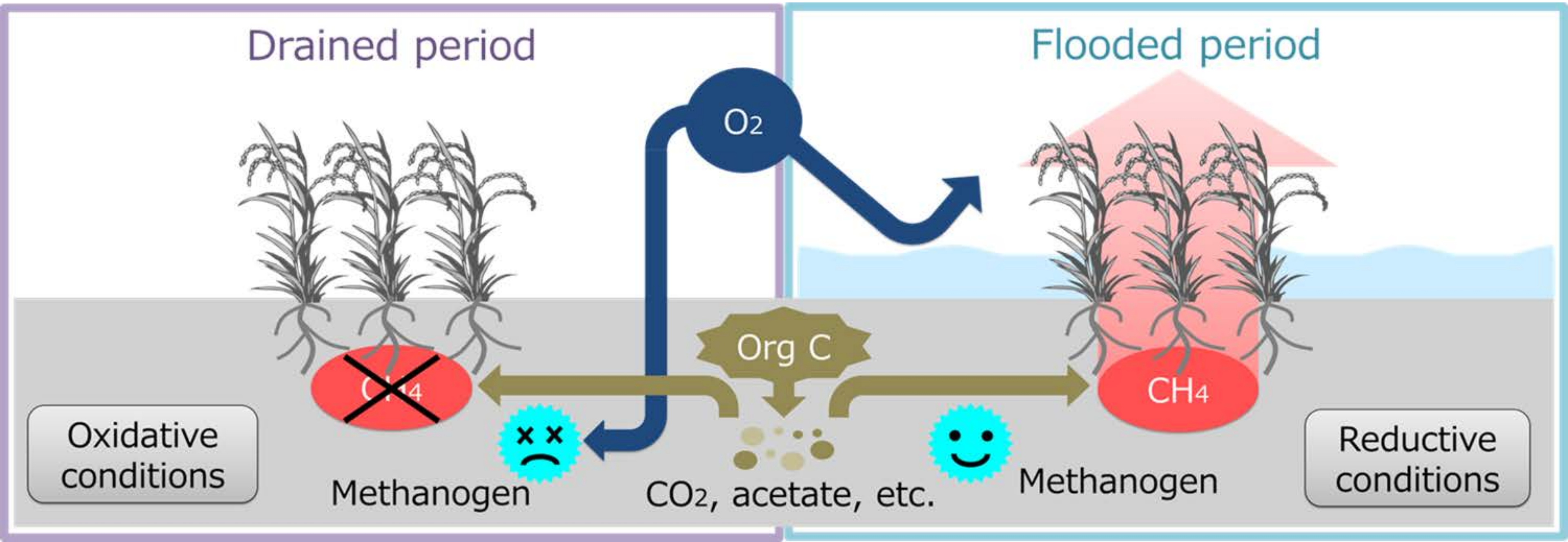
Rice cultivation: a major CH_4 source

- Accounts for ~11% of the global anthropogenic CH_4 emission (Ciais et al., 2014).
- Occupies 27% & 12% of the national GHG inventory in Vietnam & Thailand, respectively, as of 2000 (MONRE, 2010; ONREPP, 2010).



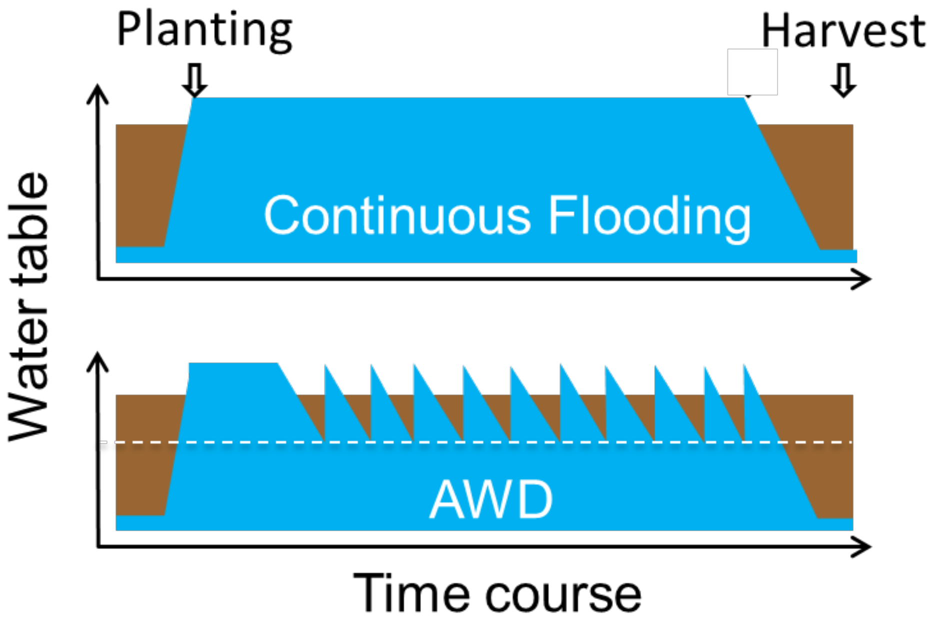
CH_4 emission from rice paddies

- Produced from organic carbon by microbes under strictly reductive soil conditions & emitted mainly through rice plants.
- Water management (i.e., soil aeration) & organic matter (e.g., straw & mature) management are the major mitigation options.



Alternate Wetting & Drying

- Water saving technique originally developed & being extended by the International Rice Research Institute.
- Also effective in mitigating paddy CH_4 emission due to soil aeration.
- Limited information on the local feasibility in terms of GHG emission, water saving, & rice productivity.



MIRSA-2 project: launch & goal

Ongoing 5-year (FY2013-2017) international research project funded by the Secretariat of the Agriculture, Forestry and Fisheries Research Council of the Ministry of Agriculture, Forestry and Fisheries of Japan.

➔ **To support the activities of GRA Paddy Rice Research Group.**

Project goal is to develop improved water management based on AWD that can always reduce CH_4+N_2O emission from irrigated rice paddies in Asian countries.

Sbj 1: Field demonstration of AWD feasibility in Southeast Asian countries

Sbj 2: Development of MRV guidelines for paddy water management

MIRSA-2 project: members

Vietnam
Hue University of Agriculture and Forestry

Thailand
The Joint Graduate School of Energy and Environment, KMUTT

Philippines
Philippine Rice Research Institute
International Rice Research Institute

Indonesia
Indonesian Agricultural Environment Research Institute

Japan
National Agriculture and Food Research Organization

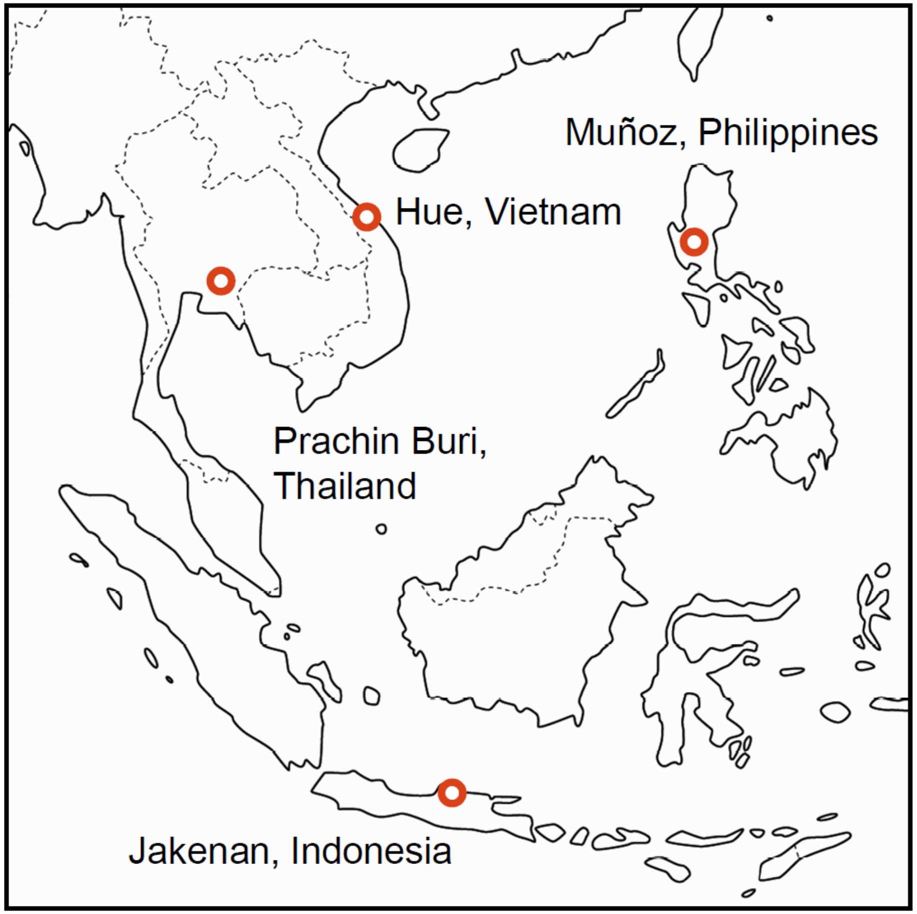
Sbj 1: field experiment

Objectives

- To assess the feasibility of AWD
- To derive the emission factor (EF) & scaling factor (SF) for CH_4 & N_2O

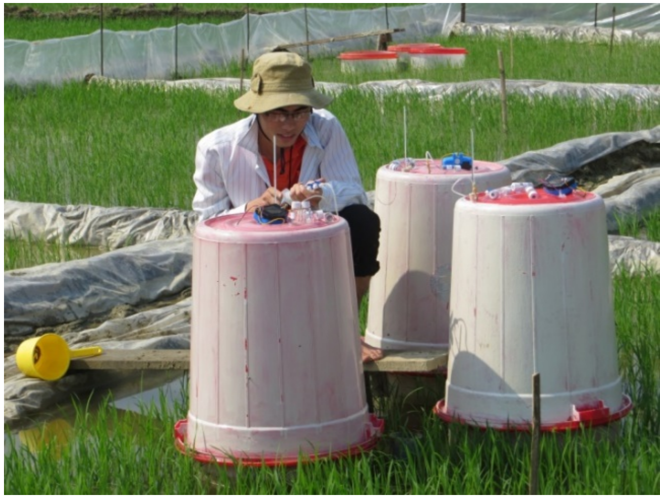
Shared settings

- 6 crops in 3 years: dry season (DS) & wet season (WS)
- 3 water management practices: continuous flooding (CF), safe-AWD with -15 cm criteria (AWD), & site-specific AWD with different criteria (AWDS)



Shared measurements

- CH_4 & N_2O fluxes
- Soil carbon content in 0-20 cm layer
- Rice grain yield
- Surface water level
- Water use (irrigation + rainfall)



Soil profile survey

(Tirol-Padre et al., submitted)

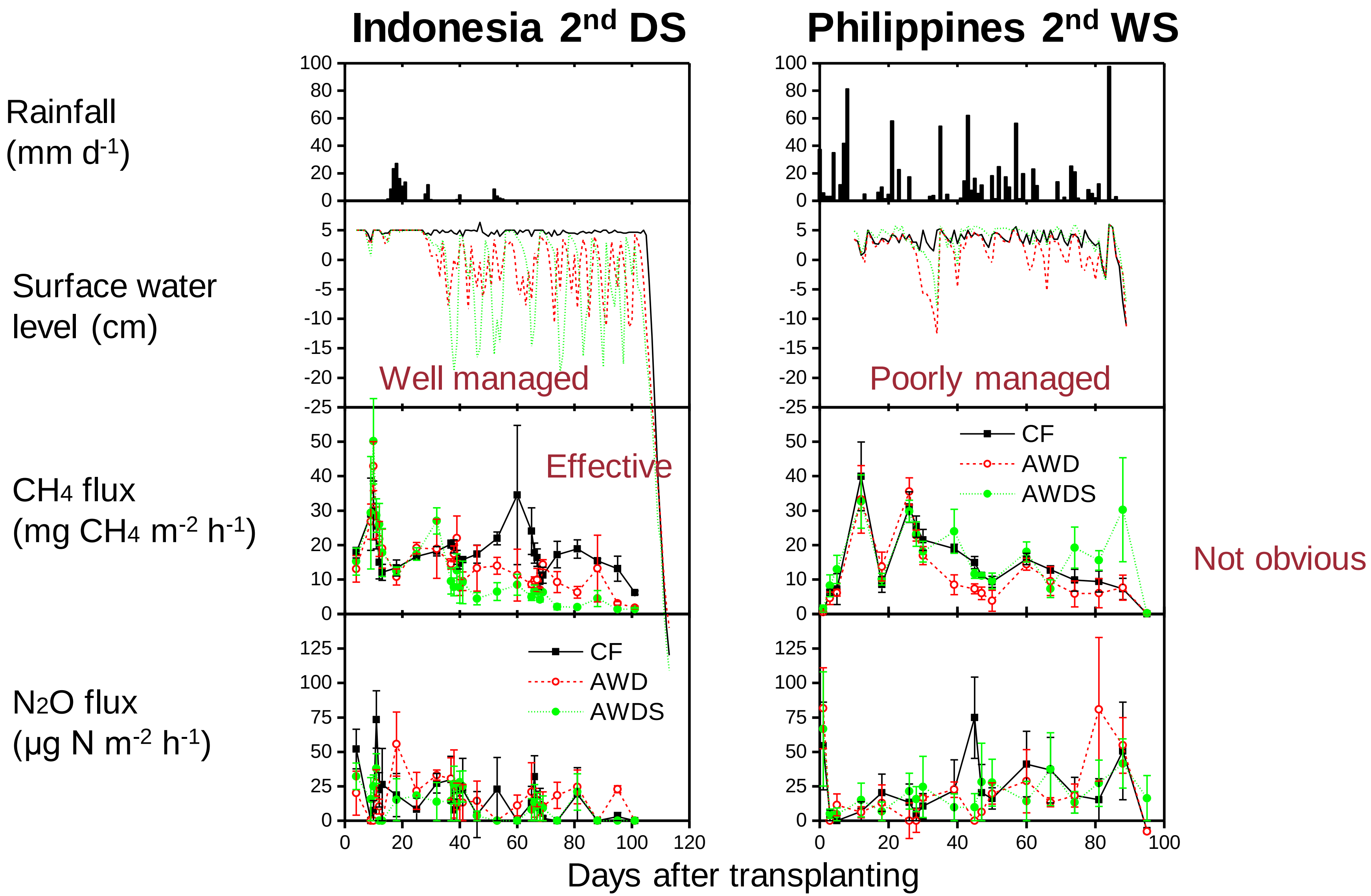
Hue Vietnam	Prachin Buri Thailand	Jakenan Indonesia	Muñoz Philippines

	Hue Vietnam	Prachin Buri Thailand	Jakenan Indonesia	Muñoz Philippines
	FAO: Dystric Fluvisols USDA: Typic Endoaquepts	USDA: Vertic Endoaquepts Active, acid isohyperthermic sulfic Endoaquepts	USDA: Aeric Endoaquepts	FAO: Ustic Epiaquert USDA: Eutric Vertisol
Texture:	Loamy	Clayey	Loamy	Clayey

Total C and N contents in 0-20 cm soil layer did not significantly differ among 3 water management practices through the 3-year experiment at each site.

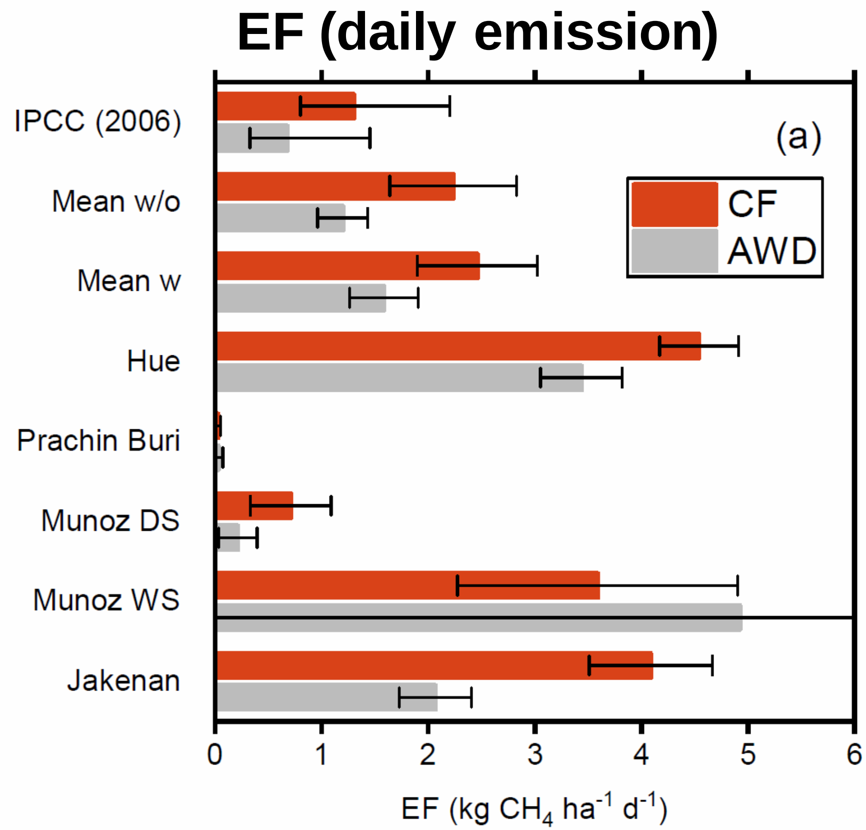
Seasonal CH_4 & N_2O fluxes

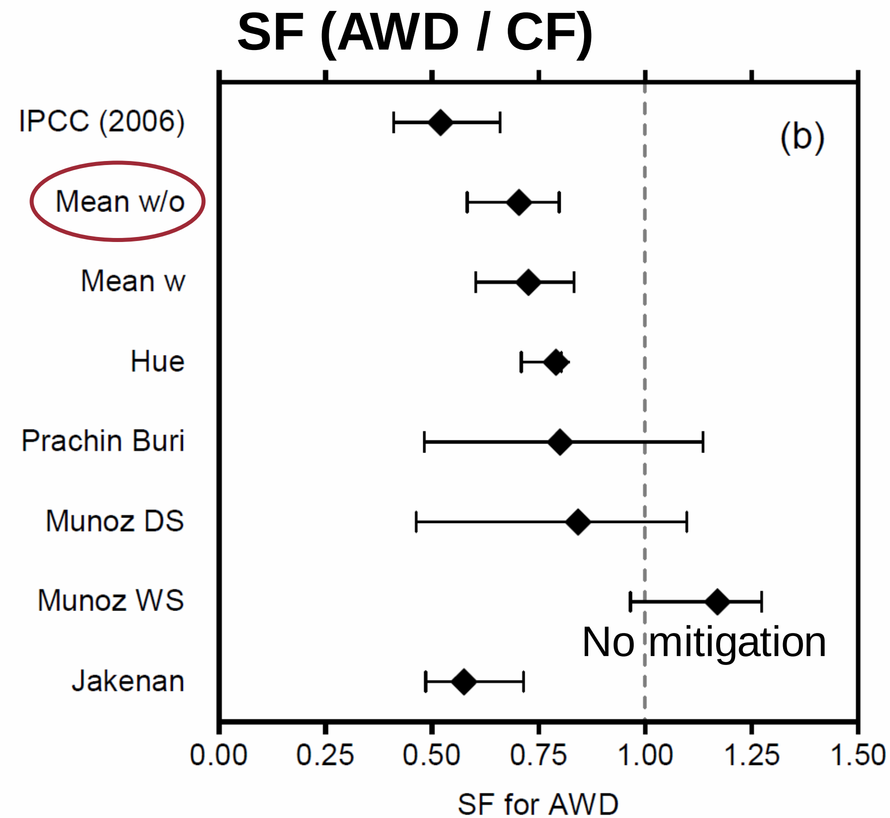
(Setyanto et al., submitted)
(Sibayan et al., submitted)



EF & SF for CH_4

(Tirol-Padre et al., submitted)





Notes

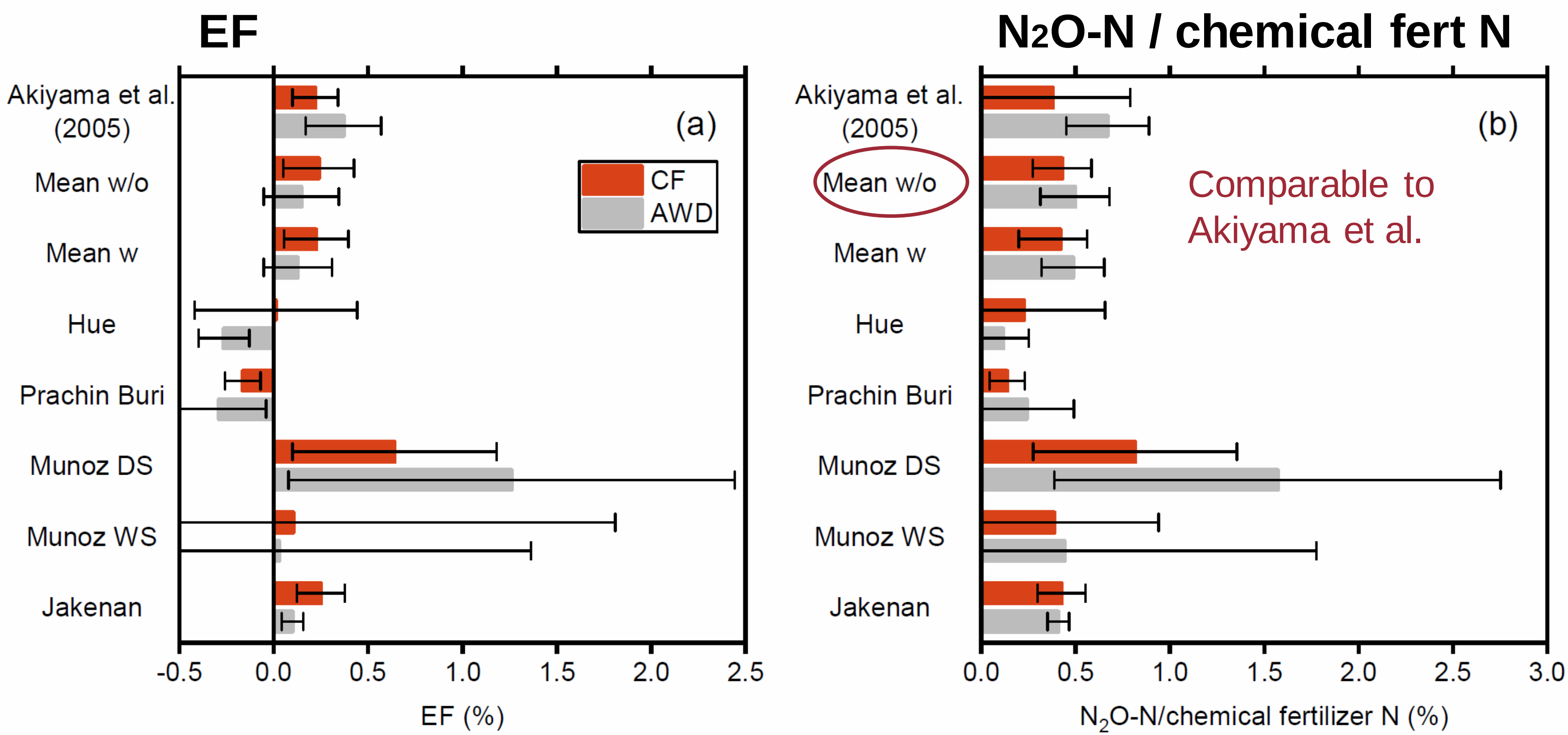
- IPCC values for multiple aeration
- Weighted mean ± bootstrapped 95%CI
- Mean w/o & w: without & with Munoz WS
- AWD and AWDS combined

Lower CH_4 mitigation effect than IPCC's default SF.

← Varying weather conditions during the field experiment.

EF for N_2O

(Tirol-Padre et al., submitted)



Notes

- Akiyama et al.'s values for midseason drainage
- EF calculated by subtracting the mean background N_2O in Akiyama et al. (2005)
- Weighted mean ± 95%CI
- Mean w/o & w: without & with Munoz WS

p value in ANOVA

(Tirol-Padre et al., submitted)
*** 0.1%, ** 1%, * 5%, † 10%

	CH_4	N_2O	GWP	Grain yield	Yield-scaled GWP	Water use
Site (S)	***	***	***	***	***	***
Dry or Wet (DW)	**	ns	**	ns	**	***
Water mgmt (WM)	*** Mitigation	No trade-off ns	** Mitigation	No negative ns	effect ns	Saving ***
S × DW	***	***	***	***	***	***
WM × S	ns	ns	*	ns	†	***
WM × DW	ns	ns	ns	ns	ns	ns
WM×DW×S	ns	ns	ns	ns	ns	*

Summary for field experiment

- The mean AWD's SF for CH_4 emission was 0.69 (95%CI: 0.61-0.77).
- In Vietnam & Indonesia sites, AWD was effective even during WS, both of which had a loamy soil.
- In Thailand & Philippines sites, AWD was unsuitable during WS due to the frequent rainfall & the slow water percolation in clayey soils.
- This study underscores the importance of practical feasibility and appropriate timing of water management in successful GHG reductions by AWD.

4 field papers & 1 synthesis paper have been submitted to a peer-reviewed international journal "Soil Science and Plant Nutrition."

Obstacles to implement mitigation options

- Development of mitigation options in rice cultivation has been advancing, but the spread to rice producers or the social implementation is limited so far.
- Rice producers can gain economic incentive through participating in a GHG mitigation project driven by carbon pricing, such as carbon tax and market mechanisms.
- MRV methodology essential to implement such projects has not been well documented for agricultural sector including rice cultivation.

Measurement, Reporting, & Verification

- A system in which the three processes are integrated to ensure the accuracy of GHG emissions and reductions from a certain project compared to the baseline practice.
- Recently, market mechanisms (i.e., internationally transferred mitigation outcomes, ITMOs) is articulated under the Paris Agreement (UNFCCC, 2015), which prescribes for the use of emission reductions realized oversees towards national emission reduction targets.

➔ Will accelerate the “institutional” spread of mitigation options.

Three approaches to implement mitigation options

(Minamikawa et al., in preparation)

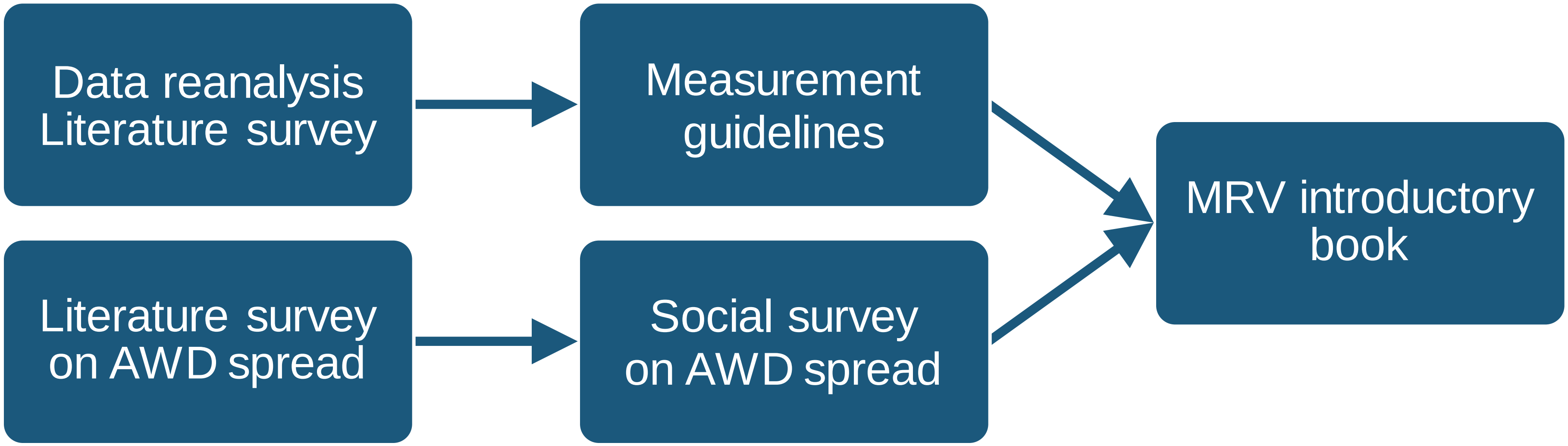
Approach	Voluntary	Semi-institutional	Institutional
Explanation	Get help from co-benefits/synergies for climate change adaptation, etc.	Domestic, voluntary subsidy or certification systems	International or domestic carbon pricing
Advantage	• No additional cost • Indirect financial incentive from improved products	• Financial incentive • Relatively easy documentation	• Financial incentive • Accountable to national GHG inventory
Drawback	• Limited mitigation capacity • Limited number of options	• Limited amount of subsidy • Limited purchasers	• Complicated documentation • (Current) low carbon price
Example	• Soil C sequestration • Early maturing variety	• A specific domestic subsidy • Eco-labelling	• CDM • JCM (Joint Crediting Mechanism, Japan)

Sbj 2: guidelines development

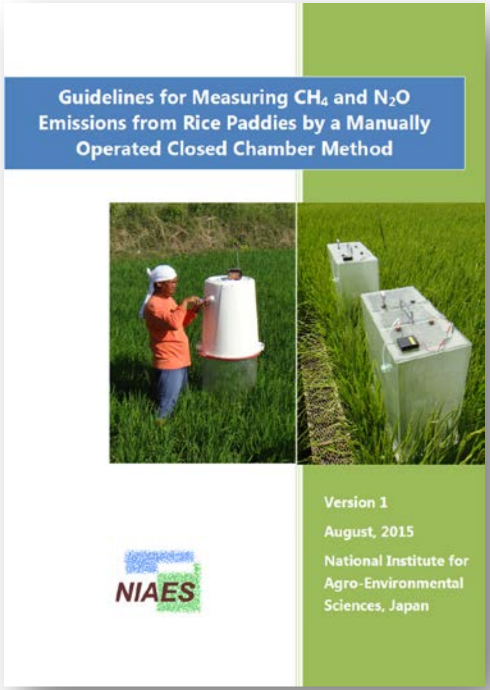
Objective

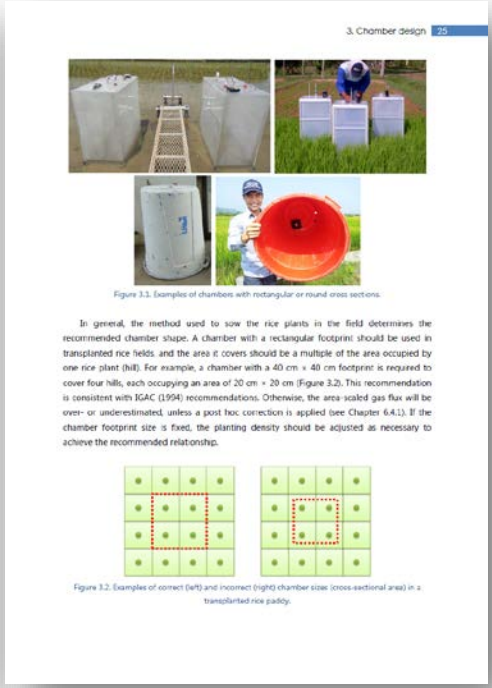
To develop the guidelines of MRV implementation for water management in irrigated rice paddies.

Process



Guidelines for chamber CH_4 & N_2O measurement





Contents

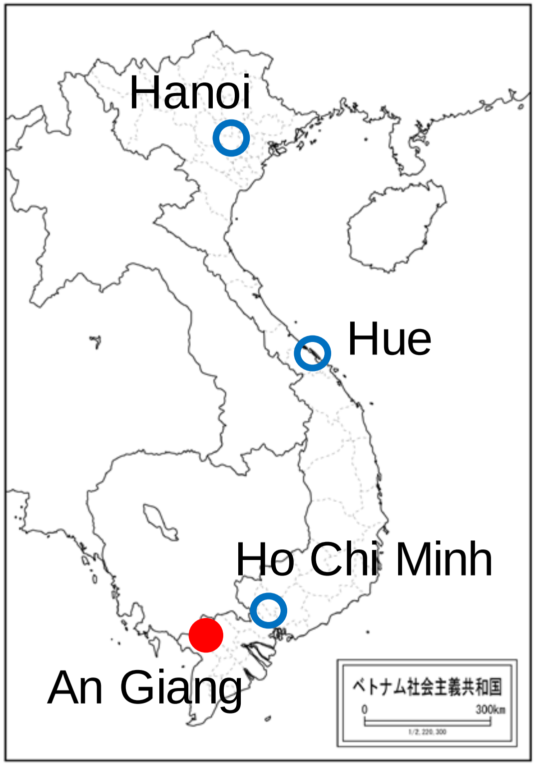
Published online in 2015 (English, 76 pp)

➔ Improves researchers' skill

➔ Can be a standard protocol of MRV

Social survey in Vietnam (Yamaguchi et al., 2016; 2017)

An Giang province is a successful case in which the provincial adoption ratio of AWD reached 53% by area in 2015 DS (SDPPAG, 2015).



A series of social surveys found that

1. Local farmers have modified the manner of AWD to meet their own objectives.
2. Co-benefits from AWD, such as decreases in rice lodging and damage, are a key in "voluntarily" spreading the technology.

Introductory book on MRV for paddy water mgmt

Features

- Provides the persons who involved/interested in agricultural MRV with basic information & the evolving issues.
- Puts emphasis on the scientific/quantitative evidence for description.
- Ready for the strictest methodology for MRV implementation capable of any mitigation projects under any programs.

Contents

1. Introduction to MRV for paddy water mngm
2. Determination of basic project design
3. Determination of advanced project design
4. Calculation of GHG emission reduction
5. Requirements for validators and verifiers

Under construction

Summary for guidelines development

Measurement guidelines

- Significance of measuring GHG emission accurately & precisely.
  ➔ Can gain economic incentive more via narrowing the uncertainty.

Social survey

- Natural & social variables influencing the local AWD spread.

MRV introductory book

- Will be published online by February 2018.
- How to put mitigation options into practice?
  ➔ Limitations in “voluntary” spread of mitigation options & the possibility of “institutional” spread.