Summary of the Workshop and Capacity Building Training on
"Rice Landscapes and Climate Change"
10-12 October 2018, Bangkok, Thailand

A – Workshop program
B – Presentations
C – Feedback and comments on workshop design and content
D – Participants list
## A – Workshop program

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Lead Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08:30-09:00</td>
<td>Registration</td>
<td>FAO</td>
</tr>
<tr>
<td>09:00-09:10</td>
<td>Opening remarks 1</td>
<td>FAO</td>
</tr>
<tr>
<td>09:10-09:15</td>
<td>Opening remarks 2</td>
<td>MAFF Japan</td>
</tr>
<tr>
<td>09:15-09:30</td>
<td>Welcome, Background to the Meeting and Objectives</td>
<td>FAO</td>
</tr>
<tr>
<td>09:30-10:30</td>
<td>Briefing Session: Significance of the Paris Agreement for Agriculture and measures for mitigation and adaptation in the agriculture sectors with a focus on rice landscapes</td>
<td>ASEAN CRN</td>
</tr>
<tr>
<td>10:30-11:00</td>
<td>Group Photo + Coffee Break</td>
<td></td>
</tr>
<tr>
<td>11:00-12:00</td>
<td>Interactive Session: Country experiences in reducing emissions and increasing resilience in rice landscapes</td>
<td>FAO</td>
</tr>
<tr>
<td>12:00-13:00</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>13:00-14:00</td>
<td>Interactive Session: Challenges and opportunities: Tackling climate change in rice landscapes (Cont.)</td>
<td>FAO</td>
</tr>
<tr>
<td>14:00-15:00</td>
<td>Knowledge Session: Current initiatives and activities in the region on reducing emissions and increasing resilience in rice landscapes</td>
<td>APEC</td>
</tr>
<tr>
<td>15:00-15:30</td>
<td>Coffee Break</td>
<td></td>
</tr>
<tr>
<td>15:30-16:00</td>
<td>Knowledge Session: Current initiatives and activities in the region on reducing emissions and increasing resilience in rice landscapes (cont.)</td>
<td>APEC</td>
</tr>
<tr>
<td>16:00-17:30</td>
<td>Knowledge Session: Current initiatives and activities in the region on reducing emissions and increasing resilience in rice landscapes</td>
<td>WBCS</td>
</tr>
<tr>
<td>17:00 –17:15</td>
<td>Wrap-up: Summary of the Day 1</td>
<td>FAO</td>
</tr>
<tr>
<td><strong>Day 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08:30-09:00</td>
<td>Registration</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Session</td>
<td>Organizer</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>09:00-09:10</td>
<td>Revisiting Workshop Objectives and Key Messages from Day 1</td>
<td>FAO</td>
</tr>
<tr>
<td>09:10-10:30</td>
<td>Knowledge Session: Capacity Building for Climate Smart Rice Cultivation in Asia</td>
<td>APEC</td>
</tr>
<tr>
<td>10:30-11:00</td>
<td>Coffee Break</td>
<td></td>
</tr>
<tr>
<td>11:00-12:30</td>
<td>Knowledge Session: Capacity Building for Climate Smart Rice Cultivation in Asia (cont.)</td>
<td>FAO</td>
</tr>
<tr>
<td>12:30-13:30</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>13:30-15:30</td>
<td>Interactive Session: Solution Matching</td>
<td>FAO</td>
</tr>
<tr>
<td>15:30 – 16:00</td>
<td>Coffee Break</td>
<td></td>
</tr>
<tr>
<td>16:00 – 17:00</td>
<td>Discussion Session : Facilitating research and investments to improve soil health and reduce emissions in rice landscapes – the way forward</td>
<td>SRP</td>
</tr>
<tr>
<td>17:00 – 17:15</td>
<td>Wrap-up: Summary and workshop evaluation</td>
<td>FAO</td>
</tr>
<tr>
<td>08:30-09:00</td>
<td>Registration</td>
<td></td>
</tr>
<tr>
<td>09:00-10:00</td>
<td>Briefing Session: Sustainable Rice Landscapes – An Introduction</td>
<td>FAO, UNEP, IRRI, WBCSD, GIZ</td>
</tr>
<tr>
<td>10:00-10:30</td>
<td>Coffee Break</td>
<td></td>
</tr>
<tr>
<td>10:30 – 11:30</td>
<td>Interactive Session: Sustainable Rice Landscapes – Developing a Regional Initiative</td>
<td>FAO, UNEP, IRRI, WBCSD, GIZ</td>
</tr>
<tr>
<td>11:30 – 12:00</td>
<td>Wrap-up: Summary and way forward</td>
<td>FAO</td>
</tr>
<tr>
<td>12:00-13:00</td>
<td>Lunch</td>
<td></td>
</tr>
</tbody>
</table>

**Day 3 – Sustainable Rice Landscapes**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Organizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00-10:00</td>
<td>Briefing Session: Sustainable Rice Landscapes – An Introduction</td>
<td>FAO, UNEP, IRRI, WBCSD, GIZ</td>
</tr>
<tr>
<td>10:30 – 11:30</td>
<td>Interactive Session: Sustainable Rice Landscapes – Developing a Regional Initiative</td>
<td>FAO, UNEP, IRRI, WBCSD, GIZ</td>
</tr>
<tr>
<td>11:30 – 12:00</td>
<td>Wrap-up: Summary and way forward</td>
<td>FAO</td>
</tr>
<tr>
<td>12:00-13:00</td>
<td>Lunch</td>
<td></td>
</tr>
</tbody>
</table>

Follow-up Afternoon Meetings organized for selected participants

<table>
<thead>
<tr>
<th>Time</th>
<th>Session I</th>
<th>Session II</th>
<th>Session III</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:00 -</td>
<td>SRL Meeting</td>
<td>GRA Paddy Rice Research Group Meeting</td>
<td>Rice/Fish systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Session I: SRL Partners</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Session II: GRA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Session III: FAO</td>
</tr>
</tbody>
</table>
B – Presentations

Workshop
1. Dr Kazunori Minamikawa, “Assessing the feasibility of GHG mitigation through water saving techniques (AWD) in irrigated rice fields in southeast Asian economies (FYs 2013-2017 funded by MAFF of Japan), Outline of the MIRSA-2 project”

2. Mr Ali Pramono, “Assessing the feasibility of GHG mitigation through water saving techniques (AWD) in irrigated rice fields in Indonesia”

3. Mr Nghia Trong Hoang, “Assessing the feasibility of GHG mitigation through water saving techniques (AWD) in irrigated rice fields in Central Vietnam”

4. Dr Amnat Chidthaisong, “Evaluating the effects of alternate wetting and drying (AWD) on methane and nitrous oxide emissions from a paddy field in Thailand”

5. Ms Kristine Samoy-Pascual, “Assessing the feasibility of GHG mitigation through water saving techniques (AWD) in irrigated rice fields in the Philippines”

Capacity Building Training
6. Dr Bjoern Ole Sander, “Analysis of suitable environments for the implementation of low-emissions technologies in rice production”

7. Dr Yasukazu Hosen, “What kind of environment should be targeted for AWD introduction? – Through experience in the Mekong Delta –”

8. Dr Kazunori Minamikawa, “MRV for a GHG mitigation project with water management in irrigated rice paddies”

9. Dr Chitnucha Buddhaboon, “The overview and plan of the Thai rice NAMA project”

10. Dr Yasuhito Shirato, “Soil C sequestration for sustainable food production and climate change mitigation”
Knowledge 1a: Current initiatives and activities in the region on reducing emissions and increasing resilience in rice landscapes

Assessing the feasibility of GHG mitigation through water saving techniques (AWD) in irrigated rice fields in southeast Asian economies (FYs 2013-2017 funded by MAFF of Japan)

Outline of the MIRSA-2 project

Kazunori Minamikawa (JIRCAS, Japan)
MIRSA-2 project funded by MAFF of Japan

Completed 5-year international research project to support the activities of GRA Paddy Rice Research Group.
⇒ Asia sub-group meeting will be held on DAY3 afternoon.

Project goal was to develop improved water management based on AWD that can always reduce CH$_4$+N$_2$O emission from irrigated rice paddies in Asian economies.

1. Field demonstration of AWD feasibility in SEA economies
⇒ This session’s topic

2. Development of MRV guidelines for paddy water mngm
⇒ My presentation’s topic on DAY2 morning

GRA, Global Research Alliance on Agricultural Greenhouse Gases
AWD, Alternate Wetting and Drying
MRV, Monitoring, Reporting and Verification
Participating economies and institutes

- **Viet Nam**, Hue University of Agriculture and Forestry
- **Thailand**, The Joint Graduate School of Energy and Environment, KMUTT
- **Philippines**, Philippine Rice Research Institute and International Rice Research Institute
- **Indonesia**, Indonesian Agricultural Environment Research Institute
- **Japan**, National Agriculture and Food Research Organization
Benefits of AWD

Originally developed and being extended by the International Rice Research Institute since 1990’s.

• Water saving for farmers
• CH$_4$ emission reduction for global environment
• Arsenic pollution control for local environment
• Negative possibilities: water stress, Cadmium pollution, N loss (N$_2$O), soil fertility, labor, etc.
**CH₄ emission from rice paddies**

- Produced from easily decomposable organic C by microbes under strictly reductive soil conditions and emitted mainly through rice plants.

- Water management creates oxidative soil conditions, and thus effectively reduces CH₄ production and emission.
Shape of continuous flooding

Direct sowing

5 cm

Soil surface

Final drainage

Harvest
Recommendation: Keep flooding to meet rice’s water demand in rooting and heading/flowering stages and to improve N-use efficiency after N topdressing.
Shared experimental protocol

Objectives

• To assess the feasibility of AWD in irrigated rice paddies
• To derive the emission factor and scaling factor for CH$_4$ and N$_2$O

Setting

• 6 crops in 3 years: both dry and wet seasons (rice double cropping)
• 3 water management practices: continuous flooding, safe AWD, and site-specific AWD (explained later)
• Manual closed chamber method
An output from MIRSA-2 project

Five papers (four field papers and one synthesis paper) published from *Soil Science and Plant Nutrition* in 2018.

Open access
Synthesis of the four field studies

Site-specific feasibility of alternate wetting and drying as a greenhouse gas mitigation option in irrigated rice fields in Southeast Asia: a synthesis

Agnes Tirol-Padre\textsuperscript{a}, Kazunori Minamikawa\textsuperscript{b}, Takeshi Tokida\textsuperscript{b}, Reiner Wassmann\textsuperscript{a,c} and Kazuyuki Yagi\textsuperscript{b}

Kazunori Minamikawa (JIRCAS, Japan)
## Agronomic practices

<table>
<thead>
<tr>
<th></th>
<th>Hue, Viet Nam</th>
<th>Jakenan, Indonesia</th>
<th>Prachin Buri, Thailand</th>
<th>Munoz, Philippines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rice variety</strong></td>
<td>HT1</td>
<td>Cisadane</td>
<td>RD41</td>
<td>NSIC Rc238</td>
</tr>
<tr>
<td><strong>Growth days</strong></td>
<td>96–120</td>
<td>107–132</td>
<td>88–98</td>
<td>81–98</td>
</tr>
<tr>
<td><strong>Crop establishment</strong></td>
<td>Wet direct sowing</td>
<td>Wet: Direct sowing</td>
<td>Pre-germinated seed sowing</td>
<td>Transplanting</td>
</tr>
<tr>
<td><strong>Chemical N</strong></td>
<td>92–120</td>
<td>120</td>
<td>70</td>
<td>90–120</td>
</tr>
<tr>
<td><strong>Chemical P</strong></td>
<td>72</td>
<td>60</td>
<td>37.5</td>
<td>40</td>
</tr>
<tr>
<td><strong>Chemical K</strong></td>
<td>62–78</td>
<td>90</td>
<td>37.5</td>
<td>40</td>
</tr>
<tr>
<td><strong>Organic amendment</strong></td>
<td>Microbial organic fertilizer</td>
<td>Farmyard manure</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Straw mngm</strong></td>
<td>Removal</td>
<td>Removal</td>
<td>Removal</td>
<td>Removal</td>
</tr>
</tbody>
</table>

* N (kg N ha\(^{-1}\) season\(^{-1}\)); P (kg P\(_2\)O\(_5\) ha\(^{-1}\) season\(^{-1}\)); K (kg K\(_2\)O ha\(^{-1}\) season\(^{-1}\)).
## Crop calendar

<table>
<thead>
<tr>
<th>Site</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hue, Viet Nam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jakenan, Indonesia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prachin Buri, Thailand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Munoz, Philippines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Dry season**
- **Dry-soil fallow**
- **Wet season**
- **Wet-soil fallow**
Soil properties

CLAYEY SOILS

Prachin Buri, Thailand
USDA: Vertic Endoaquepts

Munoz, Philippines
FAO: Dystric Fluvisols
USDA: Typic Endoaquepts

LOAMY SOILS

Hue, Vietnam
FAO: Ustic Epiaquert
USDA: Eutric Vertisol

Jakenan, Indonesia
USDA: Aeric Endoaquepts
# ANOVA statistics

<table>
<thead>
<tr>
<th></th>
<th>CH4</th>
<th>N2O</th>
<th>GWP</th>
<th>Grain yield</th>
<th>Yield-scaled GWP</th>
<th>Water use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site (S)</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Dry or wet season (DW)</td>
<td>**</td>
<td>ns</td>
<td>**</td>
<td>ns</td>
<td>**</td>
<td>***</td>
</tr>
<tr>
<td>Water mgmt (WM)</td>
<td>***</td>
<td>ns</td>
<td>**</td>
<td>ns</td>
<td>ns</td>
<td>Saving</td>
</tr>
<tr>
<td></td>
<td>Mitigation</td>
<td>Mitigation</td>
<td></td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>S × DW</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>S × WM</td>
<td>ns</td>
<td>ns</td>
<td>*</td>
<td>ns</td>
<td>ns</td>
<td>†</td>
</tr>
<tr>
<td>DW × WM</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>S × DW × WM</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>*</td>
</tr>
</tbody>
</table>

*** 0.1%, ** 1%, * 5%, † 10%

No trade-off
No negative effect
Mitigation
Saving
Inter-site variation
CH$_4$ Emission Factor

Notes
- IPCC’s baseline EFs for continuous flooding (CF) and multiple aeration
- Weighted mean ± bootstrapped 95%CI
- Mean w/o & w: without & with Munoz Philippines WS
- Safe AWD and site-specific AWD combined
- DS, dry season; WS, wet season

Large spatio-temporal variation due to different environmental and agronomic setting.
Lower CH₄ mitigation effect by AWD than IPCC’s default SF due to varying weather conditions during the field experiment.

Notes
- IPCC’s SF for multiple aeration
- Weighted mean ± bootstrapped 95%CI
- Mean w/o & w: without & with Munoz Philippines WS
- Safe AWD and site-specific AWD combined
- DS, dry season; WS, wet season
Mean ratios comparable to Akiyama et al.’s values.
Munoz’s high N₂O due to N topdressing during drained period.
The severer drainage, the lower CH$_4$ in loam

- Combination of the minimum surface water level (MinWL, cm) and the number of non-flooded days (NNFD) explained 41% of the variability in SFs for AWD in loamy soils (i.e., Viet Nam and Indonesia).
- When MinWL = -15 cm (i.e., criteria for safe AWD), 30% reduction in CH$_4$ emission can be achieved if NNFD ≥ 32 based on the predicted SF.
No negative effect on SOC decomposition.

Total C and N concentrations in 0-20 cm soil layer did not significantly differ among 3 water management practices through the 3-year experiment at each of the four sites.
Summary

- The mean CH$_4$ SF for AWD was 0.69 (95%CI: 0.61-0.77) among the four sites (Lower mitigation potential than IPCC’s SF of 0.52).
- In Viet Nam and Indonesia sites, AWD was effective even in wet seasons, both of which had a loamy soil.
- In Thailand and Philippines sites, AWD was unsuitable in wet seasons due to the frequent rainfall and the slow water percolation in clayey soils.
- The results indicate that IPCC’s SF may only be applied to irrigated rice fields where surface water level is controllable for a substantial period.
- This synthesis underscores the importance of practical feasibility and appropriate timing of water management in successful GHG reductions by AWD.
ASSESSING THE FEASIBILITY OF GHG MITIGATION THROUGH WATER SAVING TECHNIQUES (AWD) IN IRRIGATED RICE FIELDS IN INDONESIA

Ali Pramono, Terry Ayu Adrian and Helena Lina Susilawati

Indonesian Agricultural Environment Research Institute (IAERI)
Indonesian Center Agricultural Land Resources Research and Development (ICALRRD)
Indonesia Agency for Agricultural Research and Development-Ministry of Agriculture

2018
OUTLINES

• INTRODUCTION
• OBJECTIVE
• METHODS
• RESULTS
• AWD IMPLEMENTATION
• CONCLUSIONS
• FUTURE WORK
Indonesia commits to reduce GHG emission by 29 percent below business as usual in 2030 and 41 percent with international cooperation on the Leader Statement Event of the UN Framework Convention on Climate Change (UNFCCC), Conference of Parties (COP) 21, in Paris.
Percentages of Total GHG Emissions from CO$_2$-e Emitted All Sectors in Indonesia, 2012

Notes: LULUCF = Land use, land-use change, and forestry; IPPU = industrial processes and product use. Solid colors show sectors and gases covered in the analysis. Patterned colors show sectors and gases not covered in the analysis.

Source: Republic of Indonesia 2015b.

GHG emissions within the agriculture sector

Enteric Fermentation
Biomass Burning GL
Direct N2O Soils
Indirect N2O from manure

Manure Management
Liming
Indirect N2O Soils
Direct N2O from manure

Biomas Burning CL 1,103.68
Urea Fertilization
CH4 rice

Emisi Baseline
The current population of **Indonesia** is **265 million**.

**Indonesian rice field**:
- Wetland: 8,186,469 ha
- Irrigated: 4,781,494 ha
- Non irrigated: 3,404,975 ha

14 M ha of harvested area

Paddy fields in Indonesia are commonly cultivated under continuous flooding irrigation \(\rightarrow\) GHG emission

Water scarcity in the future

There is a need for the development of efficient rice cultivation methods
OBJECTIVE

To develop improved water management based on AWD that can reduce soil-derived CO$_2$-eq emission ($\text{CH}_4 + \text{N}_2\text{O}$) during rice growing season from irrigated rice paddies in Asian countries by 30% compared to the conventional practice.
METHODS

LOCATION
Indonesian Agricultural Environment Research Institute (IAERI)
Pati-Central Java Province, Indonesia

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Time period</td>
<td>128 days</td>
<td>122 days</td>
<td>123 days</td>
<td>111 days</td>
<td>129 days</td>
<td>103 days</td>
</tr>
</tbody>
</table>
1. Continuous Flooding (A1). Water height 5 cm from soil surface continuously

Plot Size → 5 m x 7 m
Plot Bund → Lined with plastic, 40 cm depth
Rice Cultivar → Cisadane (long period)
Plant Spacing → 20 cm x 20 cm

2. Safe AWD (A2). Water height 5 cm until descent to 15 cm depth

3. Site Specific AWD (A3). Water height 5 cm from soil surface and drying until 7 days before 25 DAS and 41 DAS (Season 1.2). Water height 5 cm until descent to 25 cm depth (Season 3.4.5.6)

Fertilizers Application:
1. FYM 5 Ton/Ha (17.5 Kg/plot)
2. 120 Kg N/Ha (Urea : 0.913 Kg/plot)
3. 60 Kg P2O5/Ha (SP36 : 0.583 Kg/plot)
4. 90 Kg K2O/Ha (KCl : 0.525 Kg/plot)
<table>
<thead>
<tr>
<th>No</th>
<th>Parameters</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>GHG emissions</strong></td>
<td>CH$_4$ and N$_2$O, weekly and after fertilization</td>
</tr>
<tr>
<td>2</td>
<td>Plant height and tiller number</td>
<td>Weekly</td>
</tr>
<tr>
<td>3</td>
<td><strong>Yield components</strong></td>
<td>- Grain yield&lt;br&gt;- Panicle/hill&lt;br&gt;- Grain/panicle&lt;br&gt;- Percentage of filled spikelet&lt;br&gt;- Straw biomass&lt;br&gt;- 1000 grain weight</td>
</tr>
<tr>
<td>4</td>
<td>pH and Eh measurement</td>
<td>Weekly</td>
</tr>
<tr>
<td>5</td>
<td>Climate data</td>
<td>Rainfall, max-min temperature, solar radiation</td>
</tr>
<tr>
<td>6</td>
<td>Water table measurement</td>
<td>Daily</td>
</tr>
<tr>
<td>7</td>
<td>Soil physicochemical properties</td>
<td>Texture, BD, pH, N, P, K, CEC, C organic, exchangeable cation (before and after treatments)</td>
</tr>
<tr>
<td>8</td>
<td>Amount of water irrigation</td>
<td>Total volume of water (m$^3$)</td>
</tr>
</tbody>
</table>
Kementerian Pertanian
RESULTS

Methane emissions during rice cultivation in Jakenan-Indonesia

![Graph showing methane emissions during rice cultivation in Jakenan-Indonesia]

<table>
<thead>
<tr>
<th>Season</th>
<th>CF</th>
<th>AWD</th>
<th>AWDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>218.41</td>
<td>127.70</td>
<td>106.19</td>
</tr>
<tr>
<td>S2</td>
<td>306.96</td>
<td>187.33</td>
<td>223.54</td>
</tr>
<tr>
<td>S3</td>
<td>497.04</td>
<td>321.43</td>
<td>215.29</td>
</tr>
<tr>
<td>S4</td>
<td>433.20</td>
<td>347.50</td>
<td>292.97</td>
</tr>
<tr>
<td>S5</td>
<td>590.46</td>
<td>462.86</td>
<td>455.93</td>
</tr>
<tr>
<td>S6</td>
<td>440.55</td>
<td>283.97</td>
<td>272.06</td>
</tr>
<tr>
<td>Means</td>
<td>414.44</td>
<td>288.47</td>
<td>261.00</td>
</tr>
</tbody>
</table>
### Seasonal methane emissions during rice cultivation in Jakenan-Indonesia

#### Table

<table>
<thead>
<tr>
<th>Season</th>
<th>CF</th>
<th>AWD</th>
<th>AWDS</th>
<th>Season Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Season 2013-14</td>
<td>249.7a</td>
<td>160.3a</td>
<td>158.5a</td>
<td>189.5d</td>
</tr>
<tr>
<td>Dry Season 2014</td>
<td>299.5a</td>
<td>167.1a</td>
<td>253.0a</td>
<td>239.9cd</td>
</tr>
<tr>
<td>Wet Season 2014-15</td>
<td>597.3a</td>
<td>323.2ab</td>
<td>220.6b</td>
<td>380.4b</td>
</tr>
<tr>
<td>Dry Season 2015</td>
<td>431.9a</td>
<td>302.9b</td>
<td>236.0b</td>
<td>323.6bc</td>
</tr>
<tr>
<td>Wet Season 2015-16</td>
<td>699.2a</td>
<td>539.1a</td>
<td>552.9a</td>
<td>597.1a</td>
</tr>
<tr>
<td>Dry Season 2016</td>
<td>424.6a</td>
<td>259.8b</td>
<td>243.8b</td>
<td>340.0bc</td>
</tr>
<tr>
<td><strong>Trt means</strong></td>
<td>450.4a</td>
<td>292.0b</td>
<td>277.5b</td>
<td></td>
</tr>
<tr>
<td><strong>% CH₄ Reduction</strong></td>
<td>34.5</td>
<td>37.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Graph

- **CH₄ (kg ha⁻¹ season⁻¹)**
- **Treatments:** CF, AWD, AWDS

---

*Note: The table and graph show seasonal methane emissions during rice cultivation in Jakenan-Indonesia, comparing different treatments (CF, AWD, AWDS) across various seasons.*
Measured **water levels** under AWD management in Jakenan-Indonesia

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Season 1</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CF</td>
<td>AWD</td>
<td>AWDS</td>
<td>CF</td>
<td>AWD</td>
<td>AWDS</td>
<td>CF</td>
<td>AWD</td>
<td>AWDS</td>
<td>CF</td>
<td>AWD</td>
<td>AWDS</td>
<td>CF</td>
</tr>
<tr>
<td>No. of days drained (≤0 cm)</td>
<td>0</td>
<td>20</td>
<td>14</td>
<td>0</td>
<td>31</td>
<td>16</td>
<td>0</td>
<td>38</td>
<td>44</td>
<td>0</td>
<td>41</td>
<td>38</td>
<td>1</td>
</tr>
<tr>
<td>% CH4 reduction</td>
<td>36</td>
<td>37</td>
<td></td>
<td>44</td>
<td>16</td>
<td></td>
<td>46</td>
<td>63</td>
<td></td>
<td>30</td>
<td>45</td>
<td></td>
<td>23</td>
</tr>
</tbody>
</table>

*Water saving = 17-20%*
Seasonal nitrous oxide emissions during rice cultivation in Jakenan-Indonesia

### N$_2$O kg ha$^{-1}$ season$^{-1}$

<table>
<thead>
<tr>
<th>Season</th>
<th>CF</th>
<th>AWD</th>
<th>AWDS</th>
<th>Season Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Season 2013-14</td>
<td>0.992a</td>
<td>1.009a</td>
<td>0.677a</td>
<td>0.89c</td>
</tr>
<tr>
<td>Dry Season 2014</td>
<td>1.479a</td>
<td>1.237a</td>
<td>1.390a</td>
<td>1.37b</td>
</tr>
<tr>
<td>Wet Season 2014-15</td>
<td>1.602a</td>
<td>2.222a</td>
<td>2.167a</td>
<td>2.00a</td>
</tr>
<tr>
<td>Dry Season 2015</td>
<td>0.493a</td>
<td>0.633a</td>
<td>0.356a</td>
<td>0.49cd</td>
</tr>
<tr>
<td>Wet Season 2015-16</td>
<td>0.799a</td>
<td>0.722a</td>
<td>0.810a</td>
<td>0.78c</td>
</tr>
<tr>
<td>Dry Season 2016</td>
<td>0.459a</td>
<td>0.263a</td>
<td>0.325a</td>
<td>0.35d</td>
</tr>
<tr>
<td>Trt means</td>
<td>0.971a</td>
<td>1.014a</td>
<td>0.954a</td>
<td></td>
</tr>
</tbody>
</table>
Seasonal GWP from CH$_4$ and N$_2$O emissions during rice cultivation in Jakenan-Indonesia

<table>
<thead>
<tr>
<th>Season</th>
<th>GWP Mg CO$_2$ eq ha$^{-1}$</th>
<th>Trt means</th>
<th>% GWP Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Season 2013-14</td>
<td>8.78a 5.75a 5.59a</td>
<td>15.60a</td>
<td>34.4</td>
</tr>
<tr>
<td>Dry Season 2014</td>
<td>10.62a 6.05a 9.02a</td>
<td>10.23b</td>
<td>37.7</td>
</tr>
<tr>
<td>Wet Season 2014-15</td>
<td>20.79a 11.65ab 8.15b</td>
<td>9.72b</td>
<td></td>
</tr>
<tr>
<td>Dry Season 2015</td>
<td>14.83a 10.49b 8.13b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet Season 2015-16</td>
<td>24.01a 18.55a 19.04a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry Season 2016</td>
<td>14.57a 8.91b 8.39b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Season Means</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Variations in **grain yield** over 6 seasons as affected by water management in Jakenan-Indonesia

<table>
<thead>
<tr>
<th>Season</th>
<th>Grain Yield Ton ha⁻¹</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CF</td>
<td>AWD</td>
<td>AWDS</td>
<td>Season Means</td>
<td></td>
</tr>
<tr>
<td>Wet Season 2013-14</td>
<td>6.847</td>
<td>6.363</td>
<td>6.807</td>
<td>6.672a</td>
<td></td>
</tr>
<tr>
<td>Dry Season 2014</td>
<td>5.767</td>
<td>5.597</td>
<td>5.697</td>
<td>5.687b</td>
<td></td>
</tr>
<tr>
<td>Wet Season 2014-15</td>
<td>6.944</td>
<td>6.820</td>
<td>7.263</td>
<td>7.009a</td>
<td></td>
</tr>
<tr>
<td>Dry Season 2015</td>
<td>4.939</td>
<td>4.321</td>
<td>4.734</td>
<td>4.665c</td>
<td></td>
</tr>
<tr>
<td>Wet Season 2015-16</td>
<td>6.827</td>
<td>6.814</td>
<td>6.528</td>
<td>6.723a</td>
<td></td>
</tr>
<tr>
<td>Dry Season 2016</td>
<td>4.894</td>
<td>4.967</td>
<td>4.937</td>
<td>4.933c</td>
<td></td>
</tr>
<tr>
<td><strong>Trt means</strong></td>
<td><strong>6.265a</strong></td>
<td><strong>5.983a</strong></td>
<td><strong>6.206a</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Intermittent Irrigation → ICM
CONCLUSION

- Compared to control, AWD and AWDS treatments significantly reduced the global warming potential of rice cropping systems by 35% and 38%, respectively compared to CF.

- The total water use was reduced by AWD (5%) and AWDS (6%) compared to CF.

- The adoption of AWD to rice cultivation in Indonesia will be feasible because AWD can reduce GHG emission and water use without rice yield loss.
AWD practices can reduce GWP and water use while maintain rice yields. But, the farmer will be more interested to highest rice yield. So, it is important to know the effect of AWD treatment combined the organic manure and rice cultivars on GHGs emission and rice yield on Indonesian paddy field.
Acknowledgements

The research was funded by the Ministry of Agriculture, Forestry and Fisheries of Japan through the international research project "Technology Development for Circulatory Food Production Systems Responsive to Climate Change: Development of Mitigation Options for Greenhouse Gas Emissions from Agricultural Lands in Asia (MIRSA-2)."
Assessing the feasibility of GHG mitigation through water saving techniques (AWD) in irrigated rice fields in Central Viet Nam (FYs 2013-2017 funded by MAFF of Japan)

Hoang Trong Nghia
Hue University of Agriculture and Forestry (HUAF)
Introduction

Global warming is one of the most issue for the human

- $\text{CO}_2$, $\text{CH}_4$, $\text{N}_2\text{O}$ are the top three GHGs, that’s major attributor to emissions from land use including agriculture

- Rice cultivation is a major $\text{CH}_4$ source that accounts for the total anthropogenic emission

Annual greenhouse gas emission by sector
(Source: https://www.e-education.psu.edu/geog438w/node/364)
• In Asia, traditional rice cultivation uses CF as water regime, but CF enhances CH₄ emission.
• AWD reduced water input, kept grain yield, reduced CH₄ emission.
(Source: Hasan, 2013)
What is Safe AWD?

The threshold of 15 cm water depth (below the surface) before irrigation is called ‘Safe AWD” as this will not cause any yield decline.
Vietnam is the world’s fifth largest rice producer. Rice cultivation is the largest GHG source in agriculture. CH$_4$ emission from paddy fields was estimated to be 50.5% of the agricultural GHG emission.

AWD adoption contributes to the reduction of GHG emission. Some researches on GHG emission from paddy fields in the Northern and Southern areas were reported. Limited data for the Central region.

**Objectives**

- To establish the baseline GHG emission from a paddy field in Central Vietnam.
- To investigate the feasibility of AWD in terms of GHG emission, rice productivity, and water use.

**An output from LUCCI project**

Measuring GHG Emissions from Rice Production in Quang Nam Province (Central Vietnam): Emission Factors for Different Landscapes and Water Management Practices

Authors: Agnes Tirol-Padre, Dang Hoa Tran, Trong Nghia Hoang, Duong Van Hau, Tran Thi Ngan, Le Van An, Ngo Duc Minh, Reiner Wassmann, and Bjoern Ole Sander

**Fig. Location, geography of the study area (2011-2013)**

An output from LUCCI project. LUCCI (Land Use and Climate Change Interactions in Central Vietnam). LUCCI project is an output from LUCCIi project funded by MAFF of Japan. LUCCI is an output from LUCCI project funded by MAFF of Japan.
MIRSA 2 project outline

Experimental site
- Huong An commune, Huong Tra district, Thua Thien Hue Province, Central Viet Nam during six consecutive cropping seasons from 2013 to 2016

Experimental site coordinates: 16°28′16″N; 107°31′26″E
Experimental layout

Area: 30 m² (5 m x 6 m)
Bank: 30 cm
Harvest area: 5 m²

<table>
<thead>
<tr>
<th></th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>AWD</td>
<td>AWDS</td>
<td></td>
</tr>
<tr>
<td>AWDS</td>
<td>CF</td>
<td>AWD</td>
<td></td>
</tr>
<tr>
<td>AWD</td>
<td>AWDS</td>
<td>CF</td>
<td></td>
</tr>
</tbody>
</table>

FAO: Dystric Fluvisols, USDA: Typic Endoaquepts
Gas sampling:
- Weekly in mid-morning (8:00-10:00 AM).
- 1, 2, 3, 4, and 5 days after nitrogen (N) fertilizer application.
- The gas samples were collected using a 60-mL syringe fitted with a stopcock at 0, 6, 12, 20, and 30 min after chamber closure and used a 19-mL evacuated glass vials.
Water level measurements

- Water Level Sensor was used
- Values were corrected based on manual measurements done daily using AWD tubes
Analysis gas sampling

- Gas chromatograph (8610C, SRI Instruments, CA, USA) equipped with a flame ionization detector (FID) for the analysis of CH₄ and an electron capture detector (ECD) for the analysis of N₂O.
- GWP (kg CO₂ ha⁻¹) = 28*CH₄ + 298*N₂O (IPCC, 2014)
An output from MIRSA-2 project


**Open access**

Impacts of Alternate wetting and drying on greenhouse gas emission from paddy field in Central Vietnam

---

*Dang Hoa Tran*, Trong Nghia Hoang, Takeshi Tokida, Agnes Tirol-Padre & Kazunori Minamikawa

Pages 14-22 | Received 16 May 2017, Accepted 21 Nov 2017, Published online: 30 Nov 2017

[Download citation](https://doi.org/10.1080/00380768.2017.1409601)
Fig 1. CH$_4$ and N$_2$O daily emission in Winter – Spring season
Fig 2. CH$_4$ and N$_2$O daily emission in Summer – Autumn season
Fig 3. Seasonal CH$_4$, N$_2$O emission, and GWP (kg CO$_2$ ha$^{-1}$) as affected by cropping season and water management
Fig 4. Rice grain yield (Mg ha$^{-1}$) and total water use (m$^3$ ha$^{-1}$) as affected by cropping season and water management.
Conclusion

- CH$_4$ emission ranged from 500 kg CH$_4$ ha$^{-1}$ in WS to 644 kg CH$_4$ ha$^{-1}$ in SA. Rice paddy in Central Vietnam can contribute to the national GHG budget.

- The AWD with the current criteria reduced the GWP of CH$_4$ and N$_2$O by 26% compared to CF treatment.

- The AWD with the current criteria reduced the water use by 14-15% compared to CF treatment.

- A possibility of AWD’s performance on increasing rice productivity. Thus, it will be key to spread AWD to local farmer.
Acknowledgements

• We would like to thank:
  - The Ministry of Agriculture, Forestry, Fisheries (MAFF) of Japan through MIRSA 2 project.
  - Prof. Kazuyuki Inubushi (Chiba University, Japan), Dr. Reiner Wassmann, Dr. Bjorn Ole Sander (IRRI, Philippines), and Dr. Kazuyuki Yagi (NIAES, Japan) for their valuable comments.

• Contact:
  Hoang Trong Nghia
  Hue University of Agriculture and Forestry (HUAF)
  Email: hoangtrongnghia@huaf.edu.vn
  Tell: +84 982 848 779
Thank you for your attention
Evaluating the effects of alternate wetting and drying (AWD) on methane and nitrous oxide emissions from a paddy field in Thailand

Amnat Chidthaisong\textsuperscript{1*}, Nittaya Cha-un\textsuperscript{1}, Benjamas Rossopa\textsuperscript{2}, Chitnucha Buddaboon\textsuperscript{2}, Choosak Kununthai\textsuperscript{1}, Patikorn Srithirom\textsuperscript{1}, Sirintornthep Towprayoon\textsuperscript{1}, Takeshi Tokida\textsuperscript{3}, Agnes T. Padre\textsuperscript{4}, Kazunori Minamikawa\textsuperscript{3}
An acid sulfate soil profile with mottles at PRRC site, showing a highly compacted and heterogeneous nature of a soil at this site.
### Soil Sampling Point of PRRC

<table>
<thead>
<tr>
<th>Sampling area</th>
<th>Prachinburi Rice Research Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinate</td>
<td>Nakorn Nayok map, sheet 5237 III</td>
</tr>
<tr>
<td></td>
<td>47P 739457E 1549947N</td>
</tr>
<tr>
<td>Elevation above sea level</td>
<td>3 meter</td>
</tr>
<tr>
<td>Area characteristic</td>
<td>Smooth</td>
</tr>
<tr>
<td>Slope</td>
<td>0-1 %</td>
</tr>
<tr>
<td>Geomorphology</td>
<td>Flooded by sea water in the past</td>
</tr>
<tr>
<td>Rainfall average</td>
<td>1,708 mm</td>
</tr>
<tr>
<td>Temperature average</td>
<td>28.0 °C</td>
</tr>
<tr>
<td>Climate classification</td>
<td>Savanna grassland (Aw)</td>
</tr>
<tr>
<td>Sampling date</td>
<td>June 6, 2016</td>
</tr>
</tbody>
</table>
### Soil Data Summary of PRRC

<table>
<thead>
<tr>
<th>Soil series</th>
<th>: Rangsit series (RS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil characteristic</td>
<td>: Deep soil</td>
</tr>
<tr>
<td>Soil origins</td>
<td>: Deposition of sea water or brackish water sediment</td>
</tr>
<tr>
<td>Drainage</td>
<td>: Poor</td>
</tr>
<tr>
<td>Absorption of water</td>
<td>: Slow</td>
</tr>
<tr>
<td>Erosion</td>
<td>: None</td>
</tr>
<tr>
<td>The runoff of surface water</td>
<td>: Slow</td>
</tr>
<tr>
<td>Groundwater level</td>
<td>: Less than 1.0 meter</td>
</tr>
<tr>
<td>Soil classification</td>
<td>: Very-fine, mixed, active, acid, isohyperthermic Sulfic Endoaquepts</td>
</tr>
</tbody>
</table>
To evaluate the potential of AWD for GHG mitigation, and its effects on rice productivity and water saving in an acid sulphate paddy field soil in Thailand.
Experimental design: RCB

No. of replicates: 3

No. of chambers per rep: 3

Plot size: 5m x 7m

Harvest area: 2m x 3m

Irrigation: Pumping

Field Layout

[Diagram of field layout with labels and symbols including PVC tubes, chambers, and wooden platforms with annotations for irrigation and plot dimensions.]
Gas sampling procedure

Sampling frequency: Start at 7 DAS then once a week and 1, 2, 3, 4, 5 days after fertilizer application.

Gas sampling during chamber deployment: Sampling intervals 0, 6, 12, 20 and 30 mins.

Gas sampling start time: 9.00 AM.
T1 (CF): Conventional flooding, floodwater depth 5 - 6 cm, flooded from 15 to 90 DAS

T2 (AWD): Safe AWD (Irrigate when water level is at 15 cm below soil surface) start at 37 DAS

T3 (AWDS): Site specific AWD (flexible, AWD that is more adapted to specific site)
### Field Management

<table>
<thead>
<tr>
<th>Management</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; season</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; season</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; season</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; season</th>
<th>6&lt;sup&gt;th&lt;/sup&gt; season</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; planting</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; planting</td>
</tr>
<tr>
<td>Plowing Depth</td>
<td>20 cm</td>
<td>20 cm</td>
<td>20 cm</td>
<td>20 cm</td>
<td>20 cm</td>
</tr>
<tr>
<td>Planting Method</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice variety</td>
<td>RD41</td>
<td>RD41</td>
<td>RD41</td>
<td>RD41</td>
<td>RD41</td>
</tr>
<tr>
<td>Seeding rate</td>
<td>125 kg/ha</td>
<td>125 kg/ha</td>
<td>125 kg/ha</td>
<td>125 kg/ha</td>
<td>125 kg/ha</td>
</tr>
</tbody>
</table>
Summary of 1\textsuperscript{st} to 6\textsuperscript{th} season of PRRC

<table>
<thead>
<tr>
<th></th>
<th>DS1</th>
<th>DS2</th>
<th>DS3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature ((^\circ)C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water table (cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\text{CH}_4) (mg m(^{-2}) h(^{-1}))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\text{N}_2\text{O}) (ug m(^{-2}) h(^{-1}))</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Days after sowing:
- 0, 20, 40, 60, 80, 100
Summary of 1\textsuperscript{st} to 6\textsuperscript{th} season of PRRC

Rainfall (mm)

Temperature (°C)

Water table (cm)

CH\textsubscript{4} (mg m\textsuperscript{-2} h\textsuperscript{-1})

N\textsubscript{2}O (ug m\textsuperscript{-2} h\textsuperscript{-1})
Statistical analysis results of combined seasonal means of CH$_4$, N$_2$O, grain yield and water use, with the effects of both treatment (Trt), growing season (s), and a combination of treatment and season (S × Trt).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CH$_4$‡ (kg ha$^{-1}$)</th>
<th>N$_2$O (kg ha$^{-1}$)</th>
<th>GWP‡ (kgCO$_2$e ha$^{-1}$)</th>
<th>Grain Yield (t ha$^{-1}$)</th>
<th>Yield scaled GWP (kgCO$_2$e ton$^{-1}$)</th>
<th>Water use‡ (m$^3$ ha$^{-1}$)</th>
<th>Water Productivity‡ (ton m$^{-3}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>17.3 A</td>
<td>0.785</td>
<td>857 B</td>
<td>4.50</td>
<td>0.17</td>
<td>8805 a</td>
<td>0.609 b</td>
</tr>
<tr>
<td>AWD</td>
<td>8.8 B</td>
<td>0.979</td>
<td>637 B</td>
<td>4.19</td>
<td>0.14</td>
<td>5108 c</td>
<td>1.086 a</td>
</tr>
<tr>
<td>AWDS</td>
<td>21.0 A</td>
<td>0.851</td>
<td>1097 A</td>
<td>4.44</td>
<td>0.22</td>
<td>5811 b</td>
<td>1.023 a</td>
</tr>
</tbody>
</table>

Source of Variation

<table>
<thead>
<tr>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trt</td>
</tr>
<tr>
<td>* 0.554 † 0.398 0.140 *** **</td>
</tr>
<tr>
<td>S</td>
</tr>
<tr>
<td>*** * *** *** *** *** *** ***</td>
</tr>
<tr>
<td>S × Trt</td>
</tr>
<tr>
<td>0.502 * 0.129 * 0.221 *** **</td>
</tr>
</tbody>
</table>

‡Means with different letters indicate significant difference at the 5% level for lower-case letter and at the 10% level for capital one. The asterisks †, *, ** and *** indicate the p value of <0.10, <0.05, <0.01, <0.001, respectively.
**Key findings**

- 50% reduction in methane but no significant effect on nitrous oxide emissions (AWD vs. cont. flooding)
- Effects on greenhouse gas emission are more obvious in dry than wet season
- 42% reduction in water consumption
- No significant effect on rice growth and grain yields
Thank you
Assessing the feasibility of GHG mitigation through water saving techniques (AWD) in irrigated rice fields in the Philippines

Kristine S. Pascual
Philippine Rice Research Institute

October 10, 2018
Bangkok, Thailand
Project Site

Central Luzon, Philippines

- Contributes 20% of the national rice production
- Two distinct seasons
  - Dry and Wet
Water Management

1. Continuous Flooding (CF)
2. Safe AWD
3. Site Specific AWD (AWDS)
   - Mid-season drainage
   - AWD at -25 cm

Crop Management

- Similar in all 6 cropping seasons
- In 2016 DS and WS:
  1. AWD was implemented 10 DAT
  2. Rice stubble incorporated during dry fallow tillage
Seasonal variations in daily rainfall, mean surface water level, $\text{CH}_4$ and $\text{N}_2\text{O}$ flux during **Dry season**
Seasonal variations in daily rainfall, mean surface water level, CH$_4$ and N$_2$O flux during **Wet season**
## Results

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CH$_4$ (kg CH$_4$ ha$^{-1}$)</th>
<th>N$_2$O (kg N$_2$O ha$^{-1}$)</th>
<th>GWP (kg CO$_2$ eq ha$^{-1}$)</th>
<th>Grain yield (Mg ha$^{-1}$)</th>
<th>Water use (m$^{-3}$ ha$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>69.9 DS 328.9 WS</td>
<td>1.6 DS 0.509 WS</td>
<td>2853 DS 11333 WS</td>
<td>6.9 DS 5.41 WS</td>
<td>10336 DS 10944 WS</td>
</tr>
<tr>
<td>AWD</td>
<td>42.2 DS 350.1 WS</td>
<td>3.5 DS 0.633 WS</td>
<td>2476 DS 12093 WS</td>
<td>6.88 DS 5.83 WS</td>
<td>5913 DS 9215 WS</td>
</tr>
<tr>
<td>AWDS</td>
<td>52.8 DS 374.0 WS</td>
<td>2.63 DS 0.528 WS</td>
<td>2578 DS 12874 WS</td>
<td>6.9 DS 5.42 WS</td>
<td>5012 DS 8949 WS</td>
</tr>
<tr>
<td>Season mean</td>
<td>54.9 DS 351.5 WS</td>
<td>2.58 DS 0.556 WS</td>
<td>2636 DS 12100 WS</td>
<td>6.89 DS 5.55 WS</td>
<td>7087 DS 9702 WS</td>
</tr>
</tbody>
</table>

### Treatment Means

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CH$_4$</th>
<th>N$_2$O</th>
<th>GWP</th>
<th>Grain yield</th>
<th>Water use</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>199.4 A</td>
<td>1.05 B</td>
<td>7093 A</td>
<td>6.16 A</td>
<td>10640 A</td>
</tr>
<tr>
<td>AWD</td>
<td>196.1 B</td>
<td>2.07 A</td>
<td>7284 A</td>
<td>6.35 A</td>
<td>7564 B</td>
</tr>
<tr>
<td>AWDS</td>
<td>213.4 A</td>
<td>1.58 B</td>
<td>7725 A</td>
<td>6.16 A</td>
<td>6980 B</td>
</tr>
</tbody>
</table>

1.7% reduction
Conclusions

- Implementation of AWD is feasible in DS in Central Luzon.
- The AWD with the current settings significantly reduced the seasonal total CH$_4$ emission, but the reduction rate against CF was very limited (1.7%).
- N$_2$O emission was enhanced by the AWD, and the resultant GWP of CH$_4$ and N$_2$O did not significantly differ among water management.
Feasible options that enhance the ability of AWD in reducing GHG emissions in Central Luzon, Philippines:

(1) An earlier rice residue incorporation under dry soil conditions

(2) An earlier implementation of AWD;

(3) A proper maintenance of flooded soil condition during/after N fertilizer topdressing.
Thank you
ANALYSIS OF SUITABLE ENVIRONMENTS FOR THE IMPLEMENTATION OF LOW-EMISSIONS TECHNOLOGIES IN RICE PRODUCTION

BJOERN OLE SANDER^1, VU DUONG QUY NH^2, NGUYEN THI HUE^2, MAI VAN TRINH^2, JORREL AUNARIO^1, VO THI BACH THUONG^3, REINER WASSMANN^1

^1 International Rice Research Institute, Los Baños, Philippines
^2 Institute for Agricultural Environment, Hanoi, Vietnam
^3 Nong Lam University, Ho Chi Minh City, Vietnam
HOW DOES AWD WORK?

PERFORATED TUBE FOR OBSERVING WATER LEVEL IN THE SOIL

1. Flooded field is left to dry out

2. When water level drops to a threshold (15 cm below soil surface), the field is irrigated again.

AWD SAVES UP TO 30% OF IRRIGATION WATER AND REDUCES GHG EMISSIONS BY ~50%
EMISSION HOTSPOTS IN VIETNAM

- Using advanced GHG model (landscape-DNDC) to identify emission hotspots
- Target mitigation actions
- Use as monitoring tool and to improve national inventory
GHG EMISSION ASSESSMENT IN MRD

- Evaluation of GHG data sets of 8 locations in MRD (CLUES project)
- Incl. different biophysical characteristics - detailed regional GHG emission assessment
PHENORICE VIETNAM: WHEN AND WHERE?

Jan-Apr. harvest (1.77M ha)
May-Aug. harvest (2.63M ha)
Sept.-Dec. harvest (3.08M ha)
CLIMATIC AWD SUITABILITY MAPS - VIETNAM

- Based on cropping calendar, rice extent and water balance
- Considering biophysical factors only (soil texture / percolation, rainfall, temperature, solar radiation)

Methodology: Nelson et al., 2015

Sander et al., manuscript in preparation
CLIMATIC AWD SUITABILITY ANALYSIS IN THAI BINH PROVINCE

- Based on provincial soil map 1:50,000
- High suitability: > 80% of growth duration has water deficit
- Low suitability: < 50% of growth duration has water deficit

_Sander et al., manuscript in preparation_
Socio-economic AWD Suitability Assessment

- Local experts from DARD and extension services rate various factors, e.g. elevation, farmer awareness, irrigation facilities from 1-10
- High suitability: average rating > 8
- Low suitability: average rating < 5

Legend:
- suitable low (0-0.5)
- suitable medium (0.5-0.8)
- suitable high (0.8-1)

Sander et al., manuscript in preparation
RICE GROWTH DURATION IN VIETNAM

- Shortening the time rice is in the field reduces CH4 emissions
- Analysis of rice growth duration using PhenoRice

✅ In deltas mostly short duration varieties used
✅ Some long duration traditional varieties
OTHER GHG MITIGATION OPTIONS IN RICE PRODUCTION

- Alternate wetting and drying
- Mid-season drainage
- Fertilizer deep placement
- Coated urea
- Minimum / zero tillage
- Short-duration varieties
- Low-emissions straw management
- Site-specific nutrient management
- Biochar
- Laser land leveling
- Solar bubble dryer
- . . .
RICE STRAW MANAGEMENT - PHILIPPINES

- Early 2000s: 90% of straw was burnt
- 2017: Only ~20-30% of straw is burnt and ~50-60% is incorporated
Partial straw removal provides multiple benefits:
1) retain soil health by restoring C and K
2) create profit through straw sales
3) reduce GHG compared to incorporation

Coordinated water management can minimize GHG emissions even with straw being incorporated

Romasanta et al., 2017

Tariq et al., 2016
THANK YOU VERY MUCH.

MORE INFORMATION:
ClimateChange.irri.org
GHGmitigation.irri.org
B.Sander@irri.org
What kind of environment should be targeted for AWD introduction?

- Through the experience in the Mekong Delta -

Yasukazu Hosen Ph.D.
Unit leader
Soil Biogeochemistry and Modeling Unit
Division of Climate Change
Institute for Agro-Environmental Sciences (NIAES)
National Agriculture and Food Research Organization (NARO)
Visible benefit is important for technologies to be used.

Agricultural activities

Unique local environment

GHG mitigation technologies

Benefit to farmers

Less GHG

Adopt

Unique local environment

Agricultural activities

Less GHG

Benefit to farmers

Adopt

GHG mitigation technologies

Visible benefit is important for technologies to be used.

Agricultural activities

Unique local environment

Less GHG

Benefit to farmers

Adopt

GHG mitigation technologies
## Options for reducing CH$_4$ emissions

<table>
<thead>
<tr>
<th>Field management</th>
<th>Mitigation efficiency</th>
<th>Applicability</th>
<th>Economy</th>
<th>Effects on</th>
<th>Other effects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Irrigated</td>
<td>Rainfed</td>
<td>Cost</td>
<td>Labor</td>
</tr>
<tr>
<td>Water management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midseason drainage</td>
<td>□</td>
<td>○</td>
<td>●</td>
<td>~</td>
<td>↑</td>
</tr>
<tr>
<td>Short flooding</td>
<td>□</td>
<td>○</td>
<td>●</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td>High percolation</td>
<td>□</td>
<td>○</td>
<td>●</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Soil amendments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfate fertilizer</td>
<td>□</td>
<td>○</td>
<td>○</td>
<td>↑</td>
<td>~</td>
</tr>
<tr>
<td>Oxidants</td>
<td>□</td>
<td>○</td>
<td>○</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Soil dressing</td>
<td>□</td>
<td>○</td>
<td>○</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Organic matter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composting</td>
<td>□</td>
<td>○</td>
<td>○</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Aerobic decomp.</td>
<td>□</td>
<td>○</td>
<td>○</td>
<td>~</td>
<td>↑</td>
</tr>
<tr>
<td>Burning</td>
<td>□</td>
<td>○</td>
<td>○</td>
<td>~</td>
<td>↑</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep tillage</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>No tillage</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Rotation</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>~</td>
<td>↑</td>
</tr>
<tr>
<td>Cultivar</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>~</td>
<td>~</td>
</tr>
</tbody>
</table>


A good example obtained in the Mekong Delta

AWD 1/3 less irrigation water use

- 1/3 water

50% less GHG emission 9% higher grain yield

- 1/2 GHG yield + 9%
Good benefit encourages farmers to adopt the technology.

Adopt Rice cropping:
- 1/3 Water
- 1/2 GHG

Yield + 9%
Spatial distributions of rice cropping systems in 2012, estimated with remote sensing techniques by Nguyen-Thanh Son, et al. (2014).

Location at which JIRCAS conducted a field experiment for over 5 years, a farmer’s triple-rice-cropping alluvial paddy, Tan Loi 2 Hamlet, Can Tho City.

Spatial distributions of rice cropping systems in 2012, estimated with remote sensing techniques by Nguyen-Thanh Son, et al. (2014).
Characteristics of the Mekong Delta: Abundant in water and submerged nearly throughout the year.

<table>
<thead>
<tr>
<th>Season</th>
<th>Crop Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov.</td>
<td>Winter-Spring Cropping</td>
</tr>
<tr>
<td>Feb.</td>
<td>Spring-Summer Cropping</td>
</tr>
<tr>
<td>May.</td>
<td>Summer-Autumn Cropping</td>
</tr>
<tr>
<td>Sep.</td>
<td>Flooding</td>
</tr>
</tbody>
</table>

Less water treatment during cropping seasons may become GOOD AERATION for rice.
POSITIVE effects of Less water may be greater than NEGATIVE ones in the case of the Mekong Delta?

Under water-SCARCE environments
e.g. most places where AWD has been applied for water-saving

Lack of H₂O
NEGATIVE
Gives water stress to rice

≥

POSITIVE
Gives more O₂ to paddy soil and rice

<

Under water-ABUNDANT environments
e.g. triple-rice cropping paddies in the Mekong Delta
Characteristics of the Mekong Delta: Tidal irrigation available

## Water level of the canal (m)

- **Flood**
- Spring - Summer - Autumn
- Cropping

The daily irrigation water level crosses the paddy surface altitude for about 300 days a year.

About **0.5 – 1 m canal water level difference** a day
Environment favorable for introducing a less-water environment to rice paddies

- **Water**
  - Submerged long periods a year
    - Possibility of *yield increase*
  - Abundant and controllable
    - Farmers are *not afraid* of saving water
  - Tidal irrigation available
    - Favorable in terms of water management *costs*
Environment favorable for introducing a less-water environment to rice paddies

- **Soil**
  - **Low sulfide** conc. (e.g. FeS$_2$)
    
    $2\text{FeS}_2 + 7\text{O}_2 + \text{H}_2\text{O} \rightarrow 2\text{FeSO}_4 + \text{H}_2\text{SO}_4$
    
    $4\text{FeSO}_4 + \text{O}_2 + 10\text{H}_2\text{O} \rightarrow 4\text{Fe(OH)}_3 + 4\text{H}_2\text{SO}_4$

- **Low Cd** conc. (e.g. CdS)
  
  $\text{CdS} + 2\text{O}_2 \rightarrow \text{Cd}^{2+} + \text{SO}_4^{2-}$
  
  $\text{Rice} \rightarrow \text{Humans}$
Environment favorable for introducing a less-water environment to rice paddies

- **Water**
  - Submerged long periods a year
  - Abundant and controllable
  - Tidal irrigation available

- **Soil**
  - Low sulfide conc. (e.g. FeS$_2$)
  - Low Cd conc. (e.g. CdS)
Knowledge 2a
Capacity Building for Climate Smart Rice Cultivation in Asia

MRV for a GHG mitigation project with water management in irrigated rice paddies

Kazunori Minamikawa (JIRCAS, Japan)

This study was funded by the Ministry of Agriculture, Forestry and Fisheries of Japan through the 5-year International Research Project (MIRSA-2).
Guidebooks for GHG measurement and MRV

<table>
<thead>
<tr>
<th>Target</th>
<th>Chamber paddy GHG meas. (EF &amp; SF)</th>
<th>MRV for paddy water management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Published year</td>
<td>2015 (ver. 1)</td>
<td>2018 (ver. 1)</td>
</tr>
<tr>
<td>Authors</td>
<td>Minamikawa et al.</td>
<td>Minamikawa et al.</td>
</tr>
</tbody>
</table>

Or visit the website of this workshop
Reviewers

• Mr. Kenjiro Suzuki (UNFCCC Secretariat, Germany)
• Ms. Carolyn Ching (Verified Carbon Standard, US)
• Mr. Sandro Federici (FAO, Italy)
• Dr. Andreas Wilkes (UNIQUE forestry and land use GmbH, Germany)
• Mr. Kentaro Takahashi (IGES, Japan)
Benefits of water management

• Sound rice growth and water saving for farmers
• CH$_4$ emission reduction for global environment
• Arsenic pollution control for local environment
• Negative possibilities: water stress, Cadmium pollution, N loss (N$_2$O), soil fertility, labor, etc.

➔ Because there is a limit to the dependence on the voluntary dissemination, the institutional dissemination will be a crucial key.
## Three dissemination approaches

<table>
<thead>
<tr>
<th>Explanation</th>
<th>Voluntary</th>
<th>Semi-institutional</th>
<th>Institutional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get help from benefits/synergies of climate change adaptation, etc.</td>
<td>Domestic subsidy or certification systems</td>
<td>International or domestic carbon pricing and NAMA</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Voluntary</th>
<th>Semi-institutional</th>
<th>Institutional</th>
</tr>
</thead>
<tbody>
<tr>
<td>No additional cost</td>
<td>Financial incentive</td>
<td>Financial incentive</td>
<td></td>
</tr>
<tr>
<td>Indirect financial incentive from improved products</td>
<td>Relatively easy documentation</td>
<td>Accountable to national GHG inventory</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drawback</th>
<th>Voluntary</th>
<th>Semi-institutional</th>
<th>Institutional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited mitigation capacity</td>
<td>Limited amount of subsidy</td>
<td>Complicated documentation</td>
<td></td>
</tr>
<tr>
<td>Limited number of options</td>
<td>Limited purchasers of certificated prod.</td>
<td>(Current) low carbon price</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example</th>
<th>Voluntary</th>
<th>Semi-institutional</th>
<th>Institutional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil C sequestration</td>
<td>GAP</td>
<td>CDM</td>
<td></td>
</tr>
<tr>
<td>Early maturing variety</td>
<td>Eco-labelling</td>
<td>Thai Rice NAMA</td>
<td></td>
</tr>
</tbody>
</table>
MRV required for the institutional approach

Necessary to develop MRV methodology for ensuring the accuracy and reliability of asserted CH$_4$ emission reduction by water management.

Responsible party implements monitoring and reporting processes according to the approved MRV methodology.

Third party evaluates reported achievements and implements on-site inspection according to the approved MRV methodology.

Monitoring  Reporting  Validation/Verification
Challenges for MRV in agricultural sector

1. Impact of environmental factors on GHG emissions, which complicates the separation of anthropogenic contributions from natural variability.

2. Spatial variability in GHG emissions due to varying environmental conditions across landscapes.

3. Temporal variability in background GHG emissions, which complicates setting and tracking progress toward emission reduction goals.

4. Carbon sequestration and accounting for changes in the management and ownership of different carbon pools.

5. Delayed effects of agricultural activities on GHG emissions.

6. Organizational structures and management practices specific to agricultural sector.

World Resources Institute (2014)
Typical procedure for M and R processes

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Baseline vs. project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Distinguishing project boundary</td>
<td>• Baseline water management shall be accurately identified from the past record in</td>
</tr>
<tr>
<td></td>
<td>the project area, the fields currently surrounding the project, and the crop</td>
</tr>
<tr>
<td></td>
<td>calendar.</td>
</tr>
<tr>
<td>2. Identifying emission sources, sinks, and reservoirs</td>
<td>• Project water management shall consider not only GHG emissions but also rice</td>
</tr>
<tr>
<td></td>
<td>physiology to achieve the same rice productivity as the baseline scenario.</td>
</tr>
<tr>
<td>3. Determining how to monitor emissions and activities</td>
<td></td>
</tr>
<tr>
<td>4. Establishing monitoring system</td>
<td></td>
</tr>
<tr>
<td>5. Monitoring and calculating emissions and activities</td>
<td></td>
</tr>
<tr>
<td>6. Reporting emissions and activities</td>
<td></td>
</tr>
</tbody>
</table>
Distinguishing project boundary

Recommendations

• Responsible party shall select the project area candidate where paddy water management is feasible in respect of natural and artificial conditions for irrigation and drainage.

• Project area should follow administrative boundaries as well as natural boundaries to facilitate collection of necessary information about agricultural activities.

Considerations

• Infrastructure may overcome the lack and/or surplus of water. ➔ Expanding the opportunity and area for a project.

• Water management during fallow season can also be a target. ◀ Wet/flooded soil conditions can cause substantial CH₄ emissions.

• There should be an economy of scale for a project area. ◀ Dilution of fixed MRV costs, etc.
Identifying GHG sources/sinks/reservoirs

**Recommendation**

- Responsible party shall identify all GHG sources, sinks, and reservoirs and select target GHGs and their sources, sinks, and reservoirs after taking “materiality” into consideration.

<table>
<thead>
<tr>
<th>Source</th>
<th>Sink</th>
<th>Reservoir</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH$_4$</td>
<td>Wet/flooded soil</td>
<td>Dry soil</td>
</tr>
<tr>
<td>N$_2$O</td>
<td>Wet/drained soil, “leakage” (atmospheric N deposition, N leaching and runoff)</td>
<td>None</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>Soil, fuel</td>
<td>Plants, soil$^\dagger$</td>
</tr>
</tbody>
</table>

$^\dagger$ Soil can be a CO$_2$ sink when SOC storage is not saturated, whereas soil is just a CO$_2$ reservoir when SOC storage is saturated.
Determining how to monitor emissions/activities

Recommendations

• Items that shall be monitored and reported include basic information on agricultural activities, such as water management and rice productivity.

• Criteria for appropriately implementing project water management shall be determined based on the definition of project water management, the required level of assurance, the spatial scale of project area, and the limitations imposed by MRV costs.

<table>
<thead>
<tr>
<th>Information candidate</th>
<th>Item examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather</td>
<td>Precipitation, air temperature, extreme events</td>
</tr>
<tr>
<td>Water use</td>
<td>Irrigation volume, pump fuel usage</td>
</tr>
<tr>
<td>Agricultural practices</td>
<td>Event date, fertilizer, agrochemicals</td>
</tr>
<tr>
<td>Water management</td>
<td>Surface water level, dates of irrigation and drainage</td>
</tr>
<tr>
<td>Rice productivity</td>
<td>Growth stage, disease and pests, grain yield</td>
</tr>
<tr>
<td>Soil properties</td>
<td>Moisture conditions, C concentration</td>
</tr>
</tbody>
</table>
Establishing monitoring system

Considerations

• Items and their collection methods may depend on the spatial scale of project and the required level of assurance.

• Video and photographs can be used to monitor (qualitative) items.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Monitoring method</th>
<th>Advantage/drawback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface water level</td>
<td>• Automated sensor/logger • Manual reading with gauge</td>
<td>• Direct evidence to demonstrate • Heterogeneity of soil surface level</td>
</tr>
<tr>
<td>Irrigation volume</td>
<td>• Water gauge • Estimation from pump fuel/time</td>
<td>• Applicable from field to tract • Need precip. data for correction</td>
</tr>
<tr>
<td>Soil moisture status</td>
<td>• Automated sensor/logger • Manual sampling</td>
<td>• Most scientific evidence • Need scientific background • Heterogeneity of soil surface level</td>
</tr>
<tr>
<td>Precipitation</td>
<td>• Nearby weather station • Rain gauge</td>
<td>• Applicable from field to tract • Need irrigation volume data</td>
</tr>
</tbody>
</table>
Monitoring and calculating emissions/activities

Recommendations

• Data essential for CH₄ emission calculation are (1) EF and SF, (2) the area of project, and (3) the duration of project period.
• Uncertainties associated with the calculated results should be quantified to meet the principle of “conservativeness.”

Considerations

• EF, SF, area size, and duration need to be determined in advance.
• Model simulation is a sophisticated approach for GHG calculations in a wide area, but it requires many input parameters.

\[ E = EF \times SF_w \times SF_p \times SF_o \times SF_{s,r} \times A \times Y \times GWP \]
Three currently available techniques for V

<table>
<thead>
<tr>
<th>Technique 1</th>
<th>Technique 2</th>
<th>Technique 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reviewing reported materials</strong></td>
<td><strong>Comparison with other independent datasets</strong></td>
<td><strong>On-site direct monitoring</strong></td>
</tr>
</tbody>
</table>
| GHG emissions | · Calculation equations and errors  
· Auxiliary data  
· Uncertainty range | · National inventory rep.  
· National communication  
· Published papers | · Chamber measurement |
| Area of cultivation | · Calculation errors  
· Lack of data  
· Uncertainty range | · Statistics  
· GIS-derived data  
· Published papers | · Location survey |
| Volume of irrigation and drainage | · Logbook (water gauge and pump)  
· Uncertainty range | · Precipitation data  
· Data related to irrigation | · Performance of water gauge and pump |
| Surface water level | · Logbook (water level gauge)  
· Uncertainty range | · Precipitation data | · Performance of water level gauge  
· Spatial variability |
| Straw management | · Logbook  
· Photos | · GIS-derived data (after harvest) | · Inspection (after harvest) |
The Overview and Plan of
The Thai Rice NAMA Project

Chitnucha Buddhaboon

Ubon Ratchathani Rice Research Center, Rice Department,
Ministry of Agriculture and Cooperatives, Thailand
The Project Partners
Contents

➢ Introduction

➢ The Project Overview

➢ The project plan
Introduction
Introduction
<table>
<thead>
<tr>
<th>กลุ่มที่</th>
<th>ภาค</th>
<th>สถานที่</th>
<th>ฤดูกาลการบริหาร</th>
<th>ต้นฤดูกาล</th>
<th>นิเวศภูมิ</th>
<th>ม.ค.</th>
<th>ก.พ.</th>
<th>มี.ค.</th>
<th>เม.ย.</th>
<th>พ.ค.</th>
<th>มิ.ย.</th>
<th>ก.ค.</th>
<th>ส.ค.</th>
<th>ก.ย.</th>
<th>ส.ต.</th>
<th>พ.ย.</th>
<th>ธ.ค.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.ภาค ตะวันออกเฉียงเหนือ</td>
<td>1.1 ไม่ท่วม</td>
<td>ปราป</td>
<td>น้ำแฟน/อล๊อตข้าว</td>
<td>เสร็จข้าว</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.2 ท่วม</td>
<td>ปราป</td>
<td>ทะลุข้าว</td>
<td>เสร็จข้าว</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.ภาคตะวันออกเฉียงใต้</td>
<td>2.1 ไม่ท่วม</td>
<td>ปราป</td>
<td>น้ำแฟน/อล๊อตข้าว</td>
<td>เสร็จข้าว</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.2 ท่วม</td>
<td>ปราป-1</td>
<td>ทะลุข้าว</td>
<td>เสร็จข้าว</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ปราป-2</td>
<td>ทะลุข้าว</td>
<td>เสร็จข้าว</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.ภาคตะวันออกเฉียงใต้</td>
<td>3.1 ไม่ท่วม</td>
<td>ปราป</td>
<td>ทะลุข้าว/ข้าวฟอก</td>
<td>เสร็จข้าว</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2 ท่วม</td>
<td>ปราป</td>
<td>ทะลุข้าว</td>
<td>เสร็จข้าว</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.ภาคใต้</td>
<td>4.ไม่ท่วม</td>
<td>ปราป</td>
<td>น้ำแฟน/อล๊อตข้าว</td>
<td>เสร็จข้าว</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ปราป</td>
<td>ทะลุข้าว</td>
<td>เสร็จข้าว</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

หมายเหตุ

← เขตสูงน่าข้าว强有力 | 22 จังหวัด
← ไม่มีกุศลสุกที่ข้าวผ่าน (ปลูกต่อสองปี)
← ข้าวหนักตังข้าวข้าว

Source: Rice Departments
GHG emissions in the agriculture sector: 2013

Total GHG emissions by sector: 2000–2013

GHG emission and rice cultivation

GHG emissions in the agriculture sector: 2013 (ONEP, 2017)
The Project Overview
Thai agricultural sector contributes to global efforts for climate change mitigation officially

Minister of Agriculture and Cooperatives of Thailand, and 40 participants attending the Thai Rice NAMA Project Meeting at the Ministry of Agriculture and Cooperatives (MoAC) on 20 June 2017.

https://www.asean-agrifood.org
Rice Department (RD), under the MoAC, which is a member of the National Committee on Climate Change, is the main implementing agency for the sustainable development of the rice sector. The RD participates and coordinates the implementation of the Thai Rice NAMA”. (Mr. Anan Suwannarat, Rice Department Director General (now is Permanent Secretary))
## Fact of Thai Rice NAMA

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Ministries</td>
<td>Ministry of Agriculture and Cooperatives; Ministry of Natural Resources and Environment</td>
</tr>
<tr>
<td>(Co-) Applicant</td>
<td>Deutsche Gesellschaft für Internationale Zusammenarbeit (GmbH)</td>
</tr>
<tr>
<td>Status</td>
<td>Implementation</td>
</tr>
</tbody>
</table>
Thai Rice NAMAs Project Area

Target area: Chainat, Singburi, Angtong, Supanburi, Ayuthaya and Pathumthani
Target farmers: 100,000 HHs
Overview of Thai Rice NAMA

**Goal**

To achieve transformational change through a paradigm shift from conventional to low-emission farming (AWD, chemical fertilizer and rice straw management) in Thailand

**Objectives**

- **Farmers have adopted the SRP Standard/GAP++** and thereby reduce GHG emissions and realize additional co-benefits.
- **Mitigation services** are provided in the market and utilized by the farmers to achieve SRP certification.
- **Innovative incentive schemes** are established on the national level to support the transformation of the whole rice sector to low-emission production.

**Duration**

- **5 years from Aug 2018 – Aug 2023**

**Budget**

- **14.9 million Euro**

* Thai Rice NAMA is a pilot project in developing low-carbon rice farming approach.
Project Target

- 100,000 farmer households in irrigated areas of the six target provinces (Chainat, Angthong, Pathum Thani, Singburi, Ayutthaya, and Suphanburi, and nearby watershed areas)
- Benefit 450,000 farmer household members and 2,100 mitigation service providers
- Target rice farming areas: 2,846,376 rai in wet season and 2,846,376 rai in dry season
- Total annual rice yield at 3,984,926 tons in 5th year (1,992,463 tons in wet season 2022 and 1,992,463 tons in dry season 2022/2023)*
- Reduce GHG emissions by 1.73 million tCO2eq over 5 years of project implementation

* Average yield is 0.7 ton/rai and 100% adoption rate
The Partners for the implementation the Thai Rice NAMA project

- Rice Department, Ministry of Agriculture and Cooperatives
- GIZ (The GIZ is owned by the German government)
- Office of Natural Resources and Environmental Policy and Planning
- Department of Agricultural Extension
- Royal Irrigation Department, Land Development Department
- Bank for Agriculture and Agricultural Cooperatives
- Office of Agricultural Economics
- National Bureau of Agricultural Commodity and Food Standards
Mitigation Technologies

1. Laser transmitter
2. Laser beam
3. Laser receiver
4. Tractor with control box
5. Leveling bucket

Laser Land Levelling

Harvest
Straw baler machine
Rice straw bales

Straw and Stubble Management

Flooded rice field
Field water tubes to monitor water depth
Mature rice

Alternate Wetting and Drying

Collecting soil
Testing the soil
Applying fertiliser

Site-specific Nutrient Management

https://www.asean-agrifood.org/
Financial Mechanisms

1. **BAAC**
   - Repayment
   - Profit sharing
   - Green credit loan covering initial investment
   - Payment of mitigation services

2. **NAMA Facility**
   - Initial grant through GIZ
   - Profit sharing
   - Repayment of services (for 3 years)

3. **Thai Government**
   - Contribution to training cost of low-emission rice farming practice
   - Profit sharing

4. **Revolving fund (managed by BAAC)**
   - Service provision & assessment
   - Provision of trainings
   - Low-emission rice
   - Fair price

5. **Service providers**
6. **Extension officers**
7. **Millers, Wholesalers & Retailers**
8. **Farmers**
The project plan
## The Project Plan

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prepare 1) a short project brief and FAQ for PR communication, media, press, website, 2) a long project brief for project partners and PPT presentation, and 3) value proposition for different audiences</td>
<td>GIZ</td>
</tr>
<tr>
<td>2</td>
<td>Communicate selection result to partners, embassy, and public (official letter &amp; PR)</td>
<td>GIZ</td>
</tr>
<tr>
<td>3</td>
<td>Draft executive orders for setting up: - A Policy Advisory Committee - A Project Steering Committee - Three Working Groups - Six Sub-Steering Committees at Provincial Level</td>
<td>Core Team</td>
</tr>
<tr>
<td>4</td>
<td>TORs for consultants - National Consultants (3) - International Consultants (2) - IRRI - M&amp;E consultant (if needed)</td>
<td>GIZ</td>
</tr>
<tr>
<td>5</td>
<td>Thai Rice NAMA Focal Point Meeting</td>
<td>RD/GIZ</td>
</tr>
<tr>
<td>6</td>
<td>Formalize the project between RD &amp; GIZ TH - Agreement, develop team, assign resources, procurement and set up office - Role of GIZ as NSO - Modify project plan as needed</td>
<td>RD/GIZ</td>
</tr>
</tbody>
</table>
| 7   | Formalize grant agreement between BAAC & GIZ HQ - Agreement, develop team, assign resources and procurement - Role of GIZ as NSO - Modify project plan as needed | BAAC/GIZ/R&}

| | 2018 | | | | | | | |
| Jul | Aug | Sept | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun |
| Jul | | | | | | | | | | | |
| Aug | | | | | | | | | | | |
| Sept | | | | | | | | | | | |
| Oct | | | | | | | | | | | |
| Nov | | | | | | | | | | | |
| Dec | | | | | | | | | | | |
| Jan | | | | | | | | | | | |
| Feb | | | | | | | | | | | |
| Mar | | | | | | | | | | | |
| Apr | | | | | | | | | | | |
| May | | | | | | | | | | | |
| Jun | | | | | | | | | | | |
### The Project Plan

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Responsible</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Jul</td>
<td>Aug</td>
</tr>
</tbody>
</table>
| 8   | Set up financial mechanism & business model  
- Revolving Fund Operation  
- BAAC Green Credit Operation  
- Farmer procedures & repayment  
- Business development plan for service providers | BAAC/WG3/R &R |       |      |      |      |      |      |      |      |      |      |      |      |
| 9   | Visit and provide briefing to Minister of MoAC | RD/GIZ |       |      |      |      |      |      |      |      |      |      |      |      |
| 10  | Organize official meeting with MoAC (Chaired by Minister)  
- Thai Rice NAMA Briefing  
- Policy Direction & Guidance  
- Propose Executive Orders to establish policy advisory committee, project steering committee, and working groups (Refer to Executive Orders during DPP) | RD/GIZ |       |      |      |      |      |      |      |      |      |      |      |      |
| 11  | Several Project Preparation/Implementation Meetings (3 working group levels)  
- Present a long project brief to project partners  
- Present draft executive orders for setting up six sub-steering committees at provincial level  
- Site selection  
- Technology transfer  
- Identify and cluster actions/measures and roles and responsibilities of partners for implementing project activities  
- Set up M&E working group  
- PR communication strategy  
- Role of GIZ as NSO  
- Modify project plan as needed  
- Etc. | RD/BAAC/3W Gs/GIZ/Consultants |       |      |      |      |      |      |      |      |      |      |      |      |      |
<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Responsible</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Jul</td>
<td>Aug</td>
</tr>
<tr>
<td>12</td>
<td>M&amp;E Plan Development</td>
<td>RD/OAE/GIZ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Set up baseline and data collection system (Socio-Economic benefits and MRV system)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Mitigation Technology Demonstration Plots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Organize Project Steering Committee Meeting</td>
<td>RD/GIZ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Propose results from no.6, 7, 8, 11 &amp; 12 for consideration and approval</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Propose to set up six sub-steering committees at provincial level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Organize Policy Advisory Committee Meeting</td>
<td>RD/GIZ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Propose results from no.6, 7, 8, 11, 12 &amp; 13 for consideration and approval</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Organize Six Sub-Steering Committees at Provincial Level</td>
<td>RD/GIZ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Develop detail implementation plan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Project communication and outreach to farmers</td>
<td>RD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Organize Project Kick-Off event at Provincial Level (Tentatively Ayutthaya)</td>
<td>RD/GIZ</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- PR materials (brochure, press release, short project brief)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Organize Two Project Launch Events @ MoAC and German Embassy</td>
<td>RD/BAAC/GIZ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Agreement signing ceremony</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- PR materials (brochure, press release, short project brief)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Organize Revolving Fund Kick-off Event</td>
<td>BAAC/GIZ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Prepare Thai Rice NAMA Operational Guidelines</td>
<td>Core Team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Start Land Preparation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Wet Season</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The scaling-up of climate-smart rice cultivation technologies in Thailand extends and implements along with rice policies:

- Consolidate rice farming (Big farm)
- Organic rice farming
- Niche market rice farming
- Community rice seed center
- Improving Agricultural commodity production efficiency learning center

Under the collaboration of stakeholders
Thank for all Partners and Thank for Your Attention
Soil C sequestration for sustainable food production and climate change mitigation

Yasuhito Shirato Ph.D.
Research Manager for Climate Change
Institute for Agro-Environmental Sciences (NIAES)
National Agriculture and Food Research Organization (NARO)
Soil carbon (C) sequestration & climate change mitigation

“Carbon” accumulated as black-colored “soil organic matter”

Dark-colored soils have higher concentration of carbon

Andosol (Japan) profile~ 1m
In cropland, C in “biomass” does not change in longer time-scale. Increase in SOC means decrease in atmospheric CO$_2$ → sink of CO$_2$. → Mitigation

For increasing SOC:
Increase C input or decrease decomposition rate.
### Difference between soil C sequestration and other GHGs mitigation

<table>
<thead>
<tr>
<th>Soil C sequestration</th>
<th>CH4 and N2O mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive effect on soil fertility ➔ contribute to food security</td>
<td>Emission reduction</td>
</tr>
<tr>
<td>Not only emission reduction. Possible to be “sink”</td>
<td></td>
</tr>
</tbody>
</table>
Positive correlation between soil C and crop yield

Figure 4. Relationship between winter wheat yields and values of organic C content in topsoil under different tillage systems during the period 2002 to 2009. CT – conventional tillage; NT – no tillage; MTS – minimum tillage + straw; NTM – no tillage + mulch

Mikanova et al. (2012)
Global Carbon cycle (IPCC AR5, 2013)

Atmosphere: $829 \pm 10$ Pg
(P=10$^{15}$g)

Vegetation: 450-650 Pg

Soils: 1500-2400 Pg
The 4 per 1000 initiative

- Launched in 2015 @ Paris COP 21
- Increase of 0.4% of total terrestrial SOC annually can offset annual increase in atmospheric CO2
- Climate change mitigation & sustainable agricultural production
- Over 280 partners (countries, NGOs etc.)

- Scientific & Technical Committee (STC)
- 14 scientist from the world
- Give technical advice
Criticisms

• Slogan (soil C as win-win strategy) is welcome for all, but criticisms on 0.4% target exists

1. Trade-off with other GHGs
2. Too ambitious target
3. Equilibrium and non-permanency
1. Trade-off: need to evaluate total Global Warming Potential (GWP)

* e.g. Mitigation option: “Increase C inputs to soils”

Soil C increase (CO₂ decrease)  \( \xrightarrow{\text{Trade-off}} \)  Total GWP?  \( \xrightarrow{\text{Trade-off}} \)  CH₄ and N₂O increase

Combination with other mitigation option e.g. Paddy water management to offset this
2. Too ambitious target

- 0.4% per year (slope) is not feasible quantitatively: estimates are too high globally but also locally.

- Farmers will not be able to adopt it: social and economical constraints (costs, need for continuous financial incentives).

- Large variability of SOC storage rates depending on soil type and climatic conditions and management options.

- Even an additional storage, less that 4‰ would help mitigate CO2 emissions.

- Address first the farm sustainability (SOC storage is likely to come with success in sustainable production).

- Demonstrate the benefits of soil carbon and related incentives.
3. Equilibrium and Non-permanence

- C storage is limited with time (equilibrium) and the rate of storage starts decreasing once storage is initiated.
- Non permanence of SOC storage
- Even an additional storage over a few decades would help mitigate CO2 emissions.
- Predictions must account for these kinetics.
- Management practices should be sustainable in terms of crop production.

New management (e.g. increase C input)
Advantages of paddy soils

- Slow decomposition under anaerobic condition
- Large amount of C enter soils as roots and stubbles even though straw is removed

More sustainable system than upland crop system
Let’s join the 4per1000!

• Although there are lots of criticisms
• To achieve food security and climate change mitigation

https://www.4p1000.org/c

Thank you for your attention!
C – Feedback and comments on workshop design and content

Feedback and comments on workshop design and content

Meeting participants’ expectation

Motivation/ expectation from pre-workshop survey (summarized)

- Networking, linkage, collaboration and partnership
- Gain knowledge on climate change effect on rice-based farming system and its mitigation and adaptation
- Share experiences and learn from other economies: scale up, mitigation, adaptation
- Learn mitigation technologies in rice cultivation as well as tools in monitoring, data validation of reduced emission
- Pros and cons/ trade-off of mitigation technology in rice cultivation
- Firm action plan designed to promote and implement CSA
- Learn current initiatives and practices in the region
- Exchange ideas

Response from pre-workshop survey
Respondents’ level of satisfaction

The objective of the workshop is clearly defined

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Agree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>15</td>
<td>7</td>
<td>32</td>
</tr>
</tbody>
</table>

Feedbacks

+ Informative
+ Clearly spelled out up front and checked at end of workshop
+ Well written
+ Follow the roadmap and multiple activities

The workshop achieved its intended objectives

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Agree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>15</td>
<td>13</td>
<td>27</td>
</tr>
</tbody>
</table>

Feedbacks

+ Informative
+ Multiple actions
+ Well-organized workshop
+ enthusiastic discussion
+ Clear agenda
+ Well written and clearly explained

The agenda items and topics were relevant

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Agree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>16</td>
<td>31</td>
</tr>
</tbody>
</table>

Feedbacks

+ All papers are relevant
+ topics are suitable
- Some items are too long
- Quite cramp
  - Need some successful agribusiness
  - Landscape approach
  - Roadmap
The sessions were well-structured and easy to be followed

**Feedbacks**
+ fun
+ Clear roadmap
- Confusing
  • Need time monitoring

The workshop materials and other resources are useful

**Feedbacks**
+ useful
+ Sufficient
- Picture on screen are blurred
  • Provide presentation slides in advance
  • Upload presentations instantly

The moderators and the presenters were well-prepared and knowledgable about the topic

**Feedbacks**
+ Experienced
+ Hands-on
+ Clear instruction
+ Relevant
The organizers were really accessible and helpful

Feedbacks
+ Prompt response to queries and request for assistance
+ Well-informed
- More information needed

The time allotted for each session was sufficient**

Feedbacks
+ Punctual
+ For a 3-day period it was just appropriate
- More time is needed for group work
- Too short
- Can be improved

The instructions for the interactive sessions were clear and they were well moderated

Feedbacks
+ Well explained and guided
+ Clear structure
- Can be improved
  • Make it simpler
Suggestion on workshop

Suggested topics

- Fund mobilization
- Resources management and advocacy
- Analysis of climate change situation of each country
- Climate change adaptation
- Climate value change model
- Adaptation strategy share
- Crop physiology in relation to tolerance
- Information on accounting tools of GHG emission in rice based ecosystem
- More evidence of new climate change technologies
- Institutional approach examples
- Emission factor
- Inventory of country level activities (online)

Comments on the covered topics

- Presentations has to be integrated in thinking of country-level representatives in real-time
- More technical results from country participants
- Focus more on proposal development
- More emphasize on country experience
- Best practices

Suggestion on workshop logistics

- Provide hard copy notes
- Provide participant’s contact for further collaboration
- Question/discussion per session not per presentation
- Funding session could have been through brochures
- Set up table to have more interactions
- Provide advance copies of presentation/paper materials to participants
- The menu must be varied and accommodate to all participants
- Field trip to relevant case study
Suggestion on timing

- Start 8:30 in the morning
- Arrangement for timing of presentation
- Time management
- Reduce time for game
- More accurate on time management

Suggestion on participants

- Invite other stakeholders like selected local government participants and policy makers
- Bring environment/NRM line ministries as participants in addition to ah ministries/research

Suggestion on language

- Adjustment of language especially with jargon
- More effort to accommodate participants with limited English language skills

New workshop idea

- To include or to have climate -smart- resilience - sustainable landscape & adaptation workshop
### D – Participants list

#### Participants (Speakers)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Title</th>
<th>Name</th>
<th>Position</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mr.</td>
<td>Ali Pramono</td>
<td>Researcher</td>
<td>Indonesian Agricultural Environment Research Institute, Ministry of Agriculture</td>
</tr>
<tr>
<td>2</td>
<td>Ms.</td>
<td>Kristine Samoy Pascual</td>
<td>Senior Science Research Specialist</td>
<td>Philippine Rice Research Institute</td>
</tr>
<tr>
<td>3</td>
<td>Mr.</td>
<td>Nghia Trong Hoang</td>
<td>Researcher</td>
<td>Hue University of Agriculture and Forestry</td>
</tr>
<tr>
<td>4</td>
<td>Dr.</td>
<td>Kazunori Minamikawa</td>
<td>Senior Researcher</td>
<td>Japan International Research Center for Agricultural Sciences</td>
</tr>
</tbody>
</table>

#### Participants (from the 11 travel-eligible economies only)

<table>
<thead>
<tr>
<th>Economy</th>
<th>Title</th>
<th>Name</th>
<th>Position</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile</td>
<td>Dr.</td>
<td>Viviana Becerra</td>
<td>Senior Researcher in Rice Genetics and Agronomy</td>
<td>Agricultural Research Institute of Chile (INIA)</td>
</tr>
<tr>
<td></td>
<td>Ms.</td>
<td>Sara Hube</td>
<td>Senior Researcher in Climate Change, Greenhouse Gas Emissions</td>
<td>Agricultural Research Institute of Chile</td>
</tr>
<tr>
<td>China</td>
<td>Dr.</td>
<td>QIN Xiaobo</td>
<td>Associate Professor</td>
<td>Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences</td>
</tr>
<tr>
<td></td>
<td>Dr.</td>
<td>WAN Yunfan</td>
<td>Associate Professor</td>
<td>Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Dr.</td>
<td>Helena Lina Susilawati</td>
<td>Researcher</td>
<td>Indonesian Agricultural Environment Research Institute</td>
</tr>
<tr>
<td>Economy</td>
<td>Title</td>
<td>Name</td>
<td>Position</td>
<td>Organization</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
<td>-----------------------------</td>
<td>-----------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Ms.</td>
<td>Terry Ayu Adriani</td>
<td>Researcher</td>
<td>Indonesian Agricultural Environment Research Institute</td>
</tr>
<tr>
<td>Malaysia</td>
<td>Nor Hafizah Binti Abd. Rahman</td>
<td>Agriculture Office</td>
<td>Department of Agriculture, Malaysia</td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>Mr.</td>
<td>U-Nichols Asis Manalo</td>
<td>Director-Coordinator, DA Systems-Wide Climate Change Office</td>
<td>Department of Agriculture</td>
</tr>
<tr>
<td></td>
<td>Mr.</td>
<td>Wilfredo Collado</td>
<td>Supervising Science Research Specialist</td>
<td>Philippine Rice Research Institute</td>
</tr>
<tr>
<td></td>
<td>Dr.</td>
<td>Bjoern Ole Sander</td>
<td>Senior Scientist</td>
<td>International Rice Research Institute</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>Professor</td>
<td>Pham Quang Ha</td>
<td>Deputy Director General</td>
<td>Institute for Agricultural Environment</td>
</tr>
<tr>
<td></td>
<td>Dr.</td>
<td>Vu Duong Quynh</td>
<td>Deputy Head Department of Environmental Chemistry</td>
<td>Institute for Agricultural Environment</td>
</tr>
<tr>
<td></td>
<td>Dr.</td>
<td>Dong Thi Hoang Tran</td>
<td>Lecturer</td>
<td>Hue University of Agriculture and Forestry</td>
</tr>
<tr>
<td></td>
<td>Dr.</td>
<td>Ly Hai Hoang</td>
<td>Lecturer</td>
<td>Hue University of Agriculture and Forestry</td>
</tr>
</tbody>
</table>