Application of rice husk ash and water management affect the GHG emission and water productivity in rice

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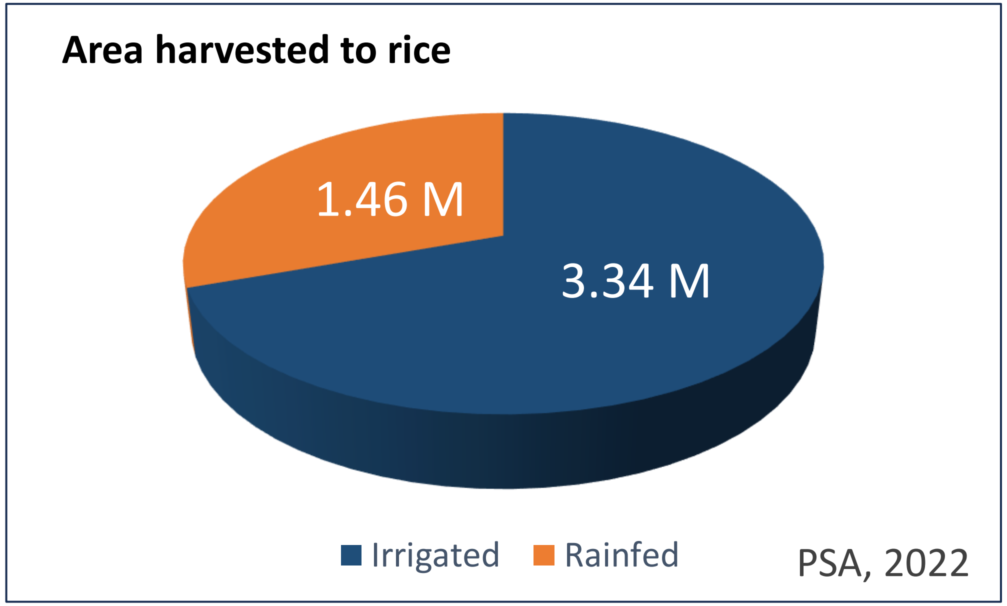
Introduction| Rice



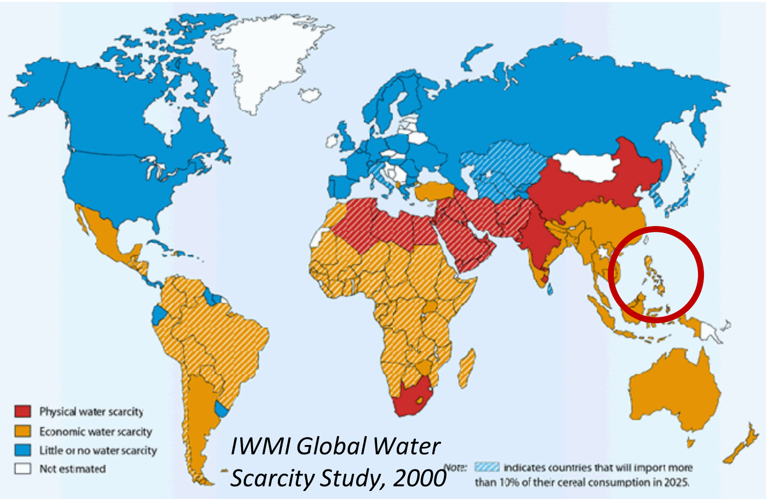
Grown in 4.8 Million ha in the Philippines with 19.8 Million metric tons production.

Common practice: soil puddling and maintaining flooded conditions throughout the crop duration.

Key issues in rice production

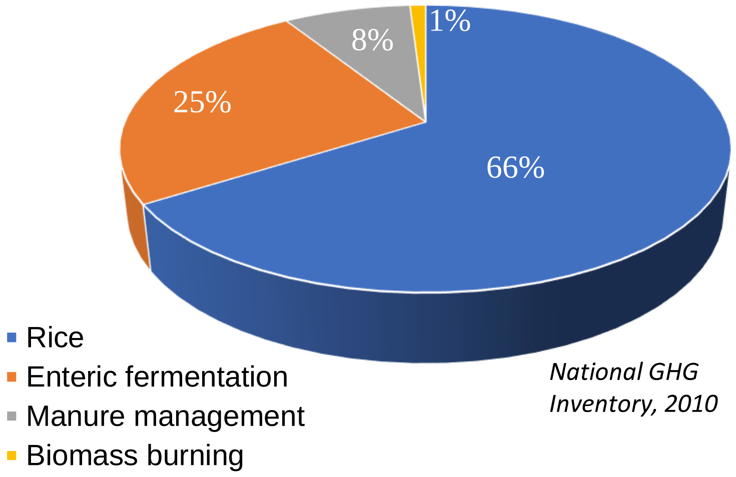
Pressure to produce more food (rice)

112.9 Million Population in the Philippines with 1.3% annual growth rate
(2023, PSA)



Irrigated rice will suffer some degree of water scarcity

- High cost of irrigation development in the Philippines
- **Water use competition:** Increasing demand for domestic water supply for example in the domestic supply in Manila



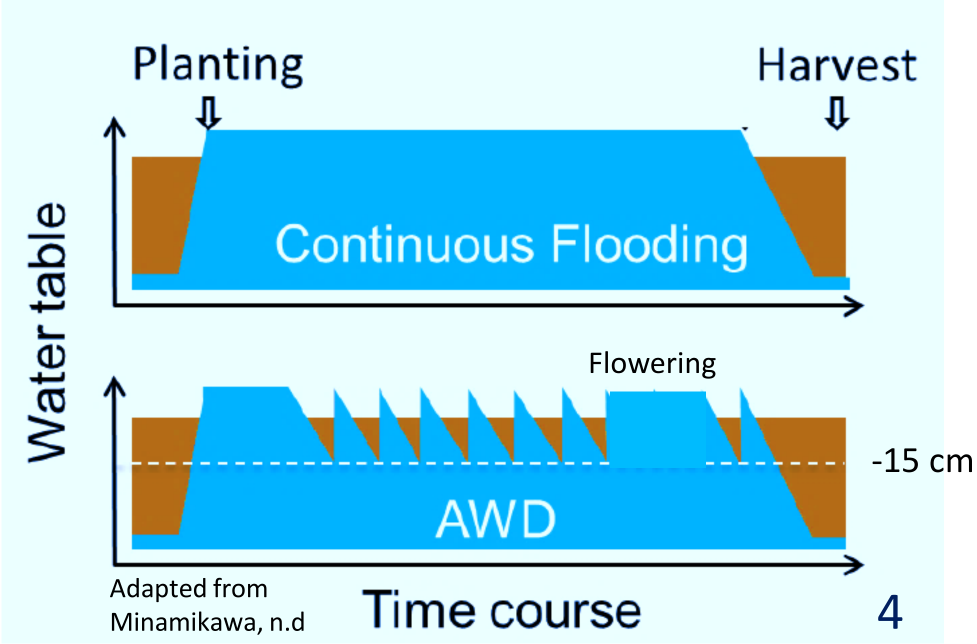
Rice is the largest source of GHG emissions in the agricultural sector

22.4 Million ton CO_2e in 2010
(NGHI, 2010)

Alternate-wetting and drying (AWD)

- A low-cost water-saving technique in rice that involves drying the field intermittently at the right time.
- A “safe” AWD is implemented at -15 cm threshold level for irrigation
- Effective in mitigating CH_4 emissions due to soil aeration

Information on the site-specific feasibility in terms of GHG emission, water saving, & rice productivity is limited.



Rice husk ash (RHA) is generated from burning rice husks from several cogeneration–power plants

Objective

This study explores the application of RHA in paddy soils under varying water management in rice.

Materials and Methods

Methods: (2-year field experiments)

- Compared AWD and continuous flooding with different rates of rice husk ash (RHA) at 0, 10, 20, and 30 t/ha: Split-plot design
- Incorporated RHA every dry season
- In 2016 DS- stubbles were dry-tilled before wetland preparation
- Transplanted 21-day old rice seedlings
- Seedling spacing: 20 x 20 cm

Measurements

- Measured the greenhouse gas emissions (CH_4 and N^2O emissions)
- Soil properties at the topsoil (0–10 cm)-
- Grain yields, water use, and water productivity

Table 1. Physicochemical properties of RHA

Parameters	Values
Moisture%	1.58
Volatile combustible matter %	1.73
Ash %	94.1
Fixed C (g kg^{-1})	41.5
Total C (g kg^{-1})	42.0
Total H (g kg^{-1})	0.16
Total N (mg kg^{-1})	1.49
Available K (g kg^{-1})	5.7
Available P (mg kg^{-1})	73.9
pH	10.7

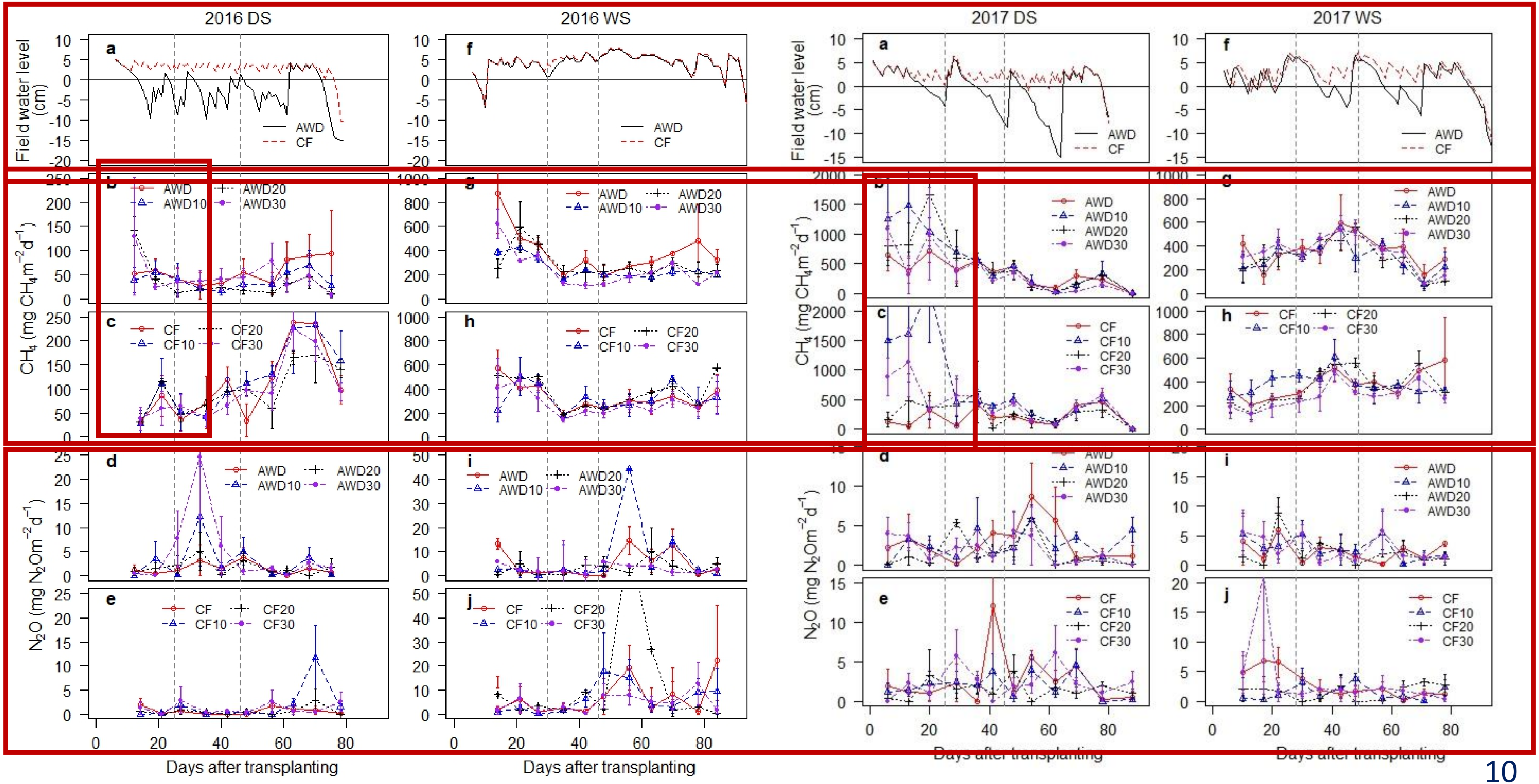


Fig. 1 Seasonal variations in field water level and CH4 and N2O emission under AWD and CF

Table 2. Soil properties in the topsoil as affected by cropping season, water management and RHA rate. DS- dry season; WS- wet season

Parameters	Bulk density Mg m^{-3}	Soil pH	Soil Organic C g kg^{-1}	Available P mg kg^{-1}	Extractable K mg kg^{-1}
Cropping Season (CS)					
2016 DS	1.20 b	6.17 b	18.6 a	27.1 a	147.6 a
2016 WS	1.36 a	5.88 c	17.7 b	10.6 b	107.7 c
2017 DS	1.19 b	6.31 a	13.6 c	5.7 c	114.2 b
2017 WS	1.35 a	6.52 a	12.3 d	2.4 d	56.9 d
Season (DW)					
DS	1.09 b	6.24	16.1	16.4 a	130.9 a
WS	1.36 a	6.20	15.0	6.5 b	82.3 b
Water (W)					
CF	1.25	6.20	15.5	11.0	108.0
AWD	1.30	6.24	15.6	11.9	105.2
Rice husk ash (RHA)					
0	1.30	6.17	14.5 b	5.1 c	77.5 c
10	1.31	6.23	15.6 a	7.7 bc	92.1 b
20	1.28	6.24	15.9 a	13.0 ab	121.4 a
30	1.21	6.23	16.2 a	19.9 a	135.5 a

Table 3. Seasonal grain yield, water use, water productivity, CH_4 and N_2O emission, and GWP and yield scaled GWP as affected by cropping season, water management, and RHA rate.

Treatments	df	Grain Yield Mg ha^{-1}	Water use m^3 ha^{-1}	Water Productivity kg m^{-3}	CH_4 kg CH_4 ha^{-1}	N_2O kg N_2O ha^{-1}	GWP kg CO_2 eq ha^{-1}	GWPy Mg CO_2 ha^{-1} Mg^{-1} grain
Cropping Season (CS)								
2016 DS		6.60 a	9301	0.94	51.1 b	[illegible]	[illegible]	0.34 c
2016 WS		5.49 c	9677	0.57	236.9 a	[illegible]	[illegible]	.77 ab
2017 DS		5.96 b	8883	1.23	342.9 a	1.85 b	12210 a	2.06 a
2017 WS		[illegible]	[illegible]	0.69	[illegible]	[illegible]	8625 b	1.50 b
Season (DW)								
DS		[illegible]	[illegible]	1.08 a	[illegible]	[illegible]	7218	1.20
WS		[illegible]	[illegible]	0.63 b	[illegible]	[illegible]	9119	1.63
Water (W)								
CF		6.01	11399 a	0.58 b	229.0	2.83	8628	1.47
AWD		5.92	6953 b	1.14 a	206.0	2.37	7710	1.37
Rice husk ash (RHA)								
0		5.92	9980	0.87	204.7	2.98 a	[illegible]	[illegible]
10		6.10	8748	0.91	257.3	2.73 ab	[illegible]	[illegible]
20		5.91	9307	0.80	212.4	2.36 b	[illegible]	[illegible]
30		5.92	8670	0.84	195.6	2.33 b	[illegible]	[illegible]
Source of variation	df							
Cropping season (CS)	3	**	ns	**	***	**	***	**
Dry or Wet (DW)[a]	1	**	ns	**	**	*	**	**
W	1	ns	**	***	†	ns	ns	ns
RHA	3	ns	ns	ns	ns	*	ns	ns
W × RHA	3	ns	ns	†	ns	ns	ns	ns
W× CS	3	ns	**	***	ns	ns	ns	ns
RHA × CS	9	ns	†	**	†	ns	*	ns
W × RHA × CS	9	ns	ns	†	ns	*	ns	ns
W × DW	1	ns	**	**	ns	ns	ns	ns
RHA × DW	3	ns	†	*	ns	ns	ns	ns
W × RHA × DW	3	ns	ns	ns	ns	ns	ns	ns

Different characters indicate significant treatment differences. df: degrees of freedom. [a]Subdivision of variation among CSs. $P < 0.10$, $*P < 0.05$, $**P < 0.01$, $***P < 0.001$.

>100 reductions of CH4 emissions

39% water savings

10% reduction of CH_4 emission

8-22% reduction of N_2O emission

Conclusions

- The primary RHA effects mitigated N_2O emissions, while AWD had only marginal effects on CH_4 emissions but maintained grain yield, and improved water productivity under our experimental conditions.
- The low total GWP in the first cropping season suggests that the additional mitigation measures of RHA application and water management need to be associated with the proper management of rice stubbles first.

Scan Me

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Thank you.

Recommendations

- **Assess Regional Variability:** Understand impacts in different agroecological contexts
- **Evaluate Economic Feasibility:** Consider costs and availability of RHA regionally
- **Tailor Practices to Local Conditions:**Customize approaches to maximize benefits and minimize trade-offs.