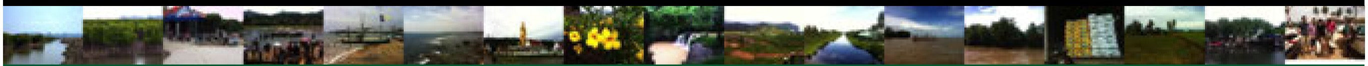

Remote Sensing and Model-Based Methane Emission Estimation from Paddy Rice Field over Bangladesh

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Introduction

Greenhous gas methane (CH_4) emission from wetland paddy rice field is account for 55% of total greenhouse gas emission from agriculture(Stocker, 2014). Global . agriculture emitting around4.6 Gt carbon dioxide equivalent (CO2-eq.) yr^{-1} in 2010 (Tubiello et al.,2013). Annually, approximately 34 million tones (Mt) of rice (7% of world rice production) are produced in Bangladesh, covering over 70% of total land (BBS, 2016). Production is expected to increase by 50% to meet the demand of an increased population with changing dietary preferences by 2050 (BBS, 2016). Agriculture is estimated to be one of the largest sources of GHG emissions in Bangladesh, estimated at 78 Tera-gram (Tg) carbon di-oxide (CO2)-eq. in 2016, to which rice cultivation contributes approximately 30% of total GHG (CO2-eq.) emitted from agriculture (FAOSTAT, 2018). Concurrently, Bangladesh is recognized as one of the world's most vulnerable countries to climate change, due to socio-economic conditions and its geographical location (Islam and Nursey-Bray, 2017). It is necessary to focus on the climate change vulnerability Bangladesh faced for the need of mitigation, and thus mitigation policy in agriculture should be developed. However, In Bangladesh, emphasis has been given to adaptation rather than mitigation, although there is potential to reduce GHG emissions from agriculture. To reduce greenhouse gas emission from rice cultivation, it's very important to proper emission estimation from rice paddy field. There are a numbers of uncertainties to estimate methane emission from rice paddy. In this study we used remote sensing-based rice and irrigated rice area map and IPCC model for methane estimation from rice paddy field in Bangladesh.

The main objective of this study to estimate methane emission from rice paddy field with remote sensing-based seasonal rice and irrigated rice area map and regional adjusted IPCC model over Bangladesh from 2001 to 2018.

Data and Methodology

The MOD13A2 Kalman's filtered NDVI and MCD12Q1 dataset used for seasonal rice area mapping. The MOD16A2 potential evapotranspiration and GSMaP effective precipitation data derived seasonal irrigated, supplementary irrigated and rainfed rice area map been used in this study. The IPCC, 2006 guideline for CH_4 emission estimation from national inventories have been used for this study. We adjusted the IPCC prescribed value based on regional characteristics of rice cultivation. Finally, we compared our result with relevant study. The overall research flow shown in figure -1.

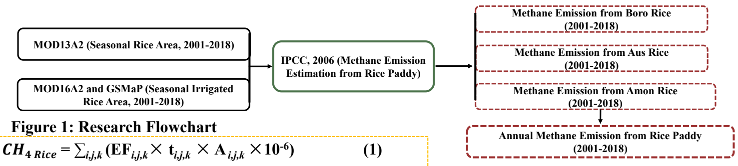

Figure 1: Research Flowchart

$$CH_{4\,Rice} = \sum_{i,j,k} (EF_{i,j,k} \times t_{i,j,k} \times A_{i,j,k} \times 10^{-6}) \quad (1)$$

$CH_{4\,Rice}$ = Annual Methane emission from rice paddy field, Gg CH_4 yr^{-1}

$EF_{i,j,k}$ = Daily Emission factors under i,j,k conditions, kg CH_4 $ha^{-1}yr^{-1}$

$t_{i,j,k}$ = Cultivation period for i, j, and k conditions, days

$A_{i,j,k}$ = Annual Rice cultivated area under *i, j and k* conditions, yr

i,j and k= Represent different ecosystems, water regimes, type and amount of organic amendments, and other condition under which CH4 emissions from rice may vary.

$$SF_O = [1 + \{(ROA_{i\,RS} \times CFOA_{i\,RS}) + (ROA_{i\,FM} \times CFOA_{i\,FM})\}]^{0.59} \quad (3)$$

$ROA_{i\,RS}$ = Application rate of rice straw (Bor o= 0.70, Aus/Amon = 0.40

$ROA_{i\,FM}$ = Application rate of Farm manure (0.60)

$CFOA_{i\,RS}$ = Conversion factor for organic amendment (Rice Straw)=1

$CFOA_{i\,FM}$ = Conversion factor for incorporated shortly before cultivation = 0.14

$$EF_i = EF_c \times SF_w \times SF_p \times SF_o \times SF_{s,r} \quad (2)$$

EF_i = Adjusted daily emission factor for cultivated rice area

EF_c = Baseline emission factor without organic amendment (IPCC default value, 1)

SF_w = Scaling factor for different water regime (Irrigated =1, Supplementary irrigated = 0.70, rainfed = 0.28)

SF_p = Scaling factor for preseason water regime before cultivation period (default value = 1)

SF_o = Scaling factor for organic amendment (*Boro* = 1.40, *Aus* = 1.31, and *Amon* = 1.26)

$SF_{s,r}$ = Scaling factor for Soil type, rice cultivar etc. (Not considered in this study)

Equation 1, 2 and 3 are based on IPCC, 2006 guideline. The parameters value are adjusted based on the rice cultivation characteristics of Bangladesh. The seasonal emission rate is used for; Boro, Aus and Amon season methane emission estimation

Result and Discussion

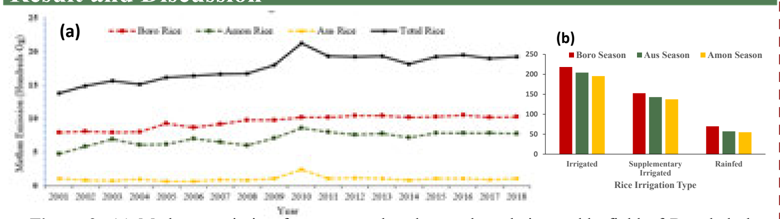

Figure 2: (a) Methane emission from seasonal and annual total rice paddy field of Bangladesh, 2001 to 2018; **(b)** Seasonal methane emission rate from irrigated, supplementary irrigated and rainfed rice paddy field (in kg ha^{-1})

Result and Discussion

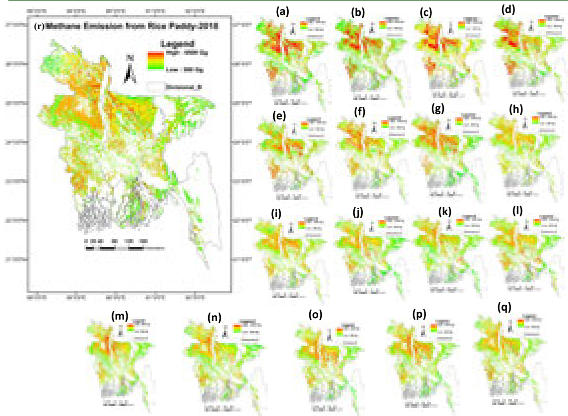

Figure 3: Annual methane emission distribution from rice paddy field of Bangladesh; (a) 2001, (b) 2002, (c) 2003, (d) 2004, (e) 2005, (f) 2006, (g) 2007, (h) 2008, (i) 2009, (j) 2010, (k) 2011, (l) 2012, (m) 2013, (n) 2014, (o) 2015, (p) 2016, (q) 2017 and (r) 2018 .

Comparison with Relevant Studies

Methods	Boro Rice	Aus Rice	Amon Rice
CH4MOD2.5	99.6 to 116.4	-	24.48
DayCent (CT)	106-140		
DayCent (AWD)	90	-	-
MODEVAL	150-251		
CH4 Flux	83-129	-	-
RS-IPCC	69.76-218.4	57.2-204.3	55.0-195.6

Figure 4: (a) Comparison of our RS-IPCC based annual methane emission from rice paddy field with FAOSTAT, EDGAR3.2, CIAT and PIK inventory estimation; **(b)** Comparison our RS-IPCC based seasonal emission rate with CH4MOD2.5, DayCent, MODEVAL and field level CH4 flux data.

Conclusion

The highest seasonal CH4 emitted from irrigated Boro (218.4 kg ha^{-1}), and lowest from rainfed Amon rice (55.0 kg ha^{-1}). The annual methane emitted from Boro, Aus and Amon rice are 1029.44 Gg, 780.91Gg and 110.05 Gg respectively. The Annual methane emission was 1384.97 Gg in 2001 and 1941.21 Gg in 2018. The methane emission from rice paddy field in Bangladesh gradually increasing over the time .

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