Info Note

Methane Emission Factors for Rice Production in the Mekong River Delta

An info note elaborating on a study of the International Rice Research Institute (IRRI) conducted by Vo et al. (2018)

Bui Tan Yen, Reiner Wassmann and Bjoern Ole Sander

JULY 2019

Key messages

- Methane emission factors at the provincial scale range from 1.08 to 7.7 kg CH4/ha/day, depending on soil type, submerging condition, and cropping season.
- In most provinces, the methane emission factor in the summer-autumn season is higher than in the other seasons.
- This compilation of emission factors is derived from the data of Vo et al. (2018), but will need updating once more emission rates become available in the future.

Agro-environmental zones of the Mekong River Delta

Rice production was recognized as a major source of methane (CH4) emission (Wassmann and Aulakh 2000). In Vietnam, rice production is estimated to contribute more than 50% of total emissions from the agriculture sector annually (MoNRE 2014). The largest CH4-emitting region in Vietnam is the Mekong River Delta (MRD) where more than 23 million tons of rice are produced annually accounting for about 55% of the Vietnamese rice production (GSO 2017).

Agro-environmental zones and methane emissions influence

The Mekong River Delta (MRD) can be divided into five agro-environmental zones with different characteristics influencing methane emissions from rice production: (1) alluvial zone, (2) acid sulphate zone, (3) saline zone, (4) deep flood zone and (5) elevated zone (Fig. 1). A map of the agro-environmental zones was generated based on the soil map of MRD at a scale of 1:250,000 (Ton That Chieu et al. 1989) and the flooding map of the delta simulated for the middle of a flooding season in a normal flooding year under the CLUES project (Phong et al. 2016; Wassmann et al. 2019).

1. The **alluvial zone** is located in the middle of the delta. Soils in this zone were generated from deposited alluvial materials of the Mekong River. This zone comprises the bulk of the favorable rice fields along the river branches. Land use in this zone is intensive with two to three rice crops per year.

2. The zone dominated by **acid sulphate soils** covers the area surrounding the alluvial zone. Acid sulphate soils are used to cultivate one or two rice crops per year. In acid sulphate soils with shallow sulfidic materials (0-50cm), special soil and water management practices must be applied to avoid oxidization of the topsoil. The sulphuric material can influence methane emissions. Rice cultivation in soil with deep sulfidic materials (>50cm) can be practiced similar to what applies to alluvial soils.

3. The **deep flood zone** is located in the northern part of the delta, mostly in the provinces of Long An, Dong Thap, and An Giang. Water level in this zone may rise above 1.5m during flooding season (August to November). This strongly influences rice cultivation practice, as well as cropping calendar and GHG emissions.

IRRI
CGIAR
RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security
CCAFS

However, a large area of this zone is used for double or triple rice production.

4. The **saline zone** covers the coastal area of the delta. Rice production in this zone is often affected by salinity intrusion, especially during the dry season (December to April). The zone is dominated by rice-based systems such as rice-cash crop or rice-shrimp. Shortage of irrigation water is the main challenge for agricultural production in this zone. Methane emissions, though, are often low in this zone.

5. The **elevated zone** includes disconnected elevated fields in the north of Dong Thap and Long An provinces, close to the Cambodian border. Cropping rotation in this zone is mainly rice-rice-cash crops. Soil in this zone belongs to the degraded soil group.

Field experiments

Field experiments were conducted in four out of five agro-environmental zones in the MRD, including the alluvial, acid sulphate, deep flood, and saline zones (Vo et al. 2018). The experiments were set up to measure the methane emission factor (EF) (kg/ha/day) under "standard" conditions (i.e., continuously flooded with limited crop residue incorporation) in three main cropping seasons: winter-spring (November to February), summer-autumn (March to June) and autumn-winter (July to October).

No field experiments were carried out in the autumn-winter season for the alluvial and acid sulphate zones, and in summer-autumn season for the saline zone. This means that the average of EFs measured in the other cropping seasons in the same zone has been adapted for the estimations presented here.

Acid sulphate soil in the MRD is often covered by alluvial materials. Rice cultivation practices on the acid sulphate soil with only deep (>50cm) sulfidic materials are the same with those in alluvial soils wherein emissions are not influenced by the sulphuric material. We therefore assigned the same EFs for the alluvial zone. Similarly, no field experiment was conducted in the elevated zone. We assumed that the EF from rice fields in this zone is the same as the rate in the alluvial zone. Note, however, that this might be inaccurate.

In the MRD, methane emission rates from rice production vary largely, depending on cropping season and agro-environmental zone. Relatively low EFs were found in the saline zone while the highest EF was recorded in the deep flood zone during the rainy season (Tab. 1).

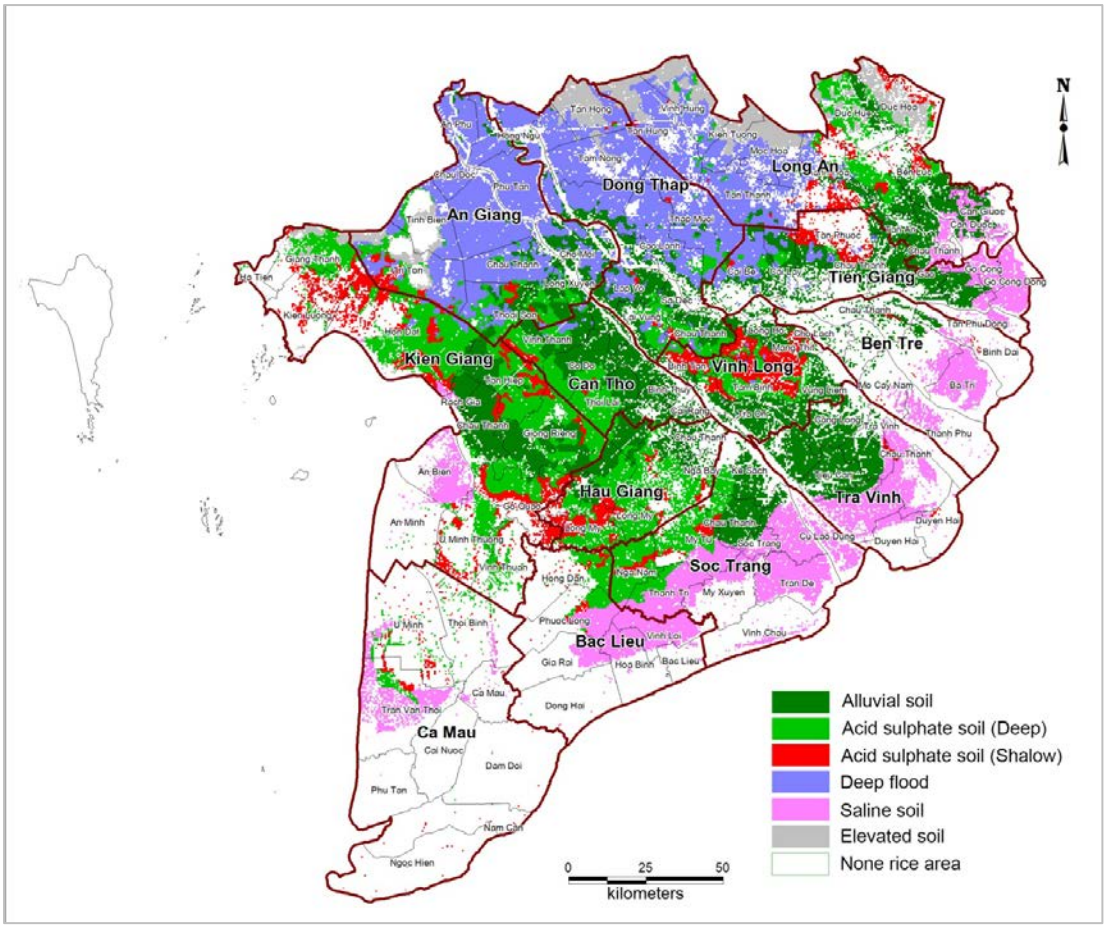

Figure 1. Distribution of rice land (2016) in the Mekong River Delta by agro-environmental zone

Area-weighted emission factors by province

The area and distribution of rice land in the MRD in 2016 were extracted from a high resolution land use map of the Lower Mekong Region (Servir Mekong 2019). The spatio-temporal information obtained from analyzing time series of satellite images from 2015-2016 using the PhenoRice method (Boschetti et al. 2017) was used to estimate the seasonal EFs (kg/ha/day) of MRD provinces for the three cropping seasons (Table 2), including winter-spring (2015/16), summer-autumn (2016) and autumn-winter (2016). The values for provinces differ because each province covers more than one agro-environmental zone. In this regard, the EFs have been weighted by the respective share of total rice area per zone and season.

Overall, seasonal EFs in the winter-spring season are lower than in other seasons, varying from 1.08 (Ben Tre) to 2.65 kg CH4/ha/day (An Giang and Dong Thap). The EF in the summer-autumn season is the highest in 9 out of 13 provinces. For provinces covering the deep flood zone, especially An Giang and Dong Thap, EF in the autumn-winter season is relatively high, reaching values higher than 7 kg CH4/ha/day. In principle, the EFs could further be disaggregated to district level. This data base, however, is not included in this info note due to size constraints.

Table 1. Methane emission factors (kg CH_4/ha/d) from rice fields in the MRD by season and zone

Cropping season	Alluvial zone	Acid sulphate zone		Deep flood zone	Saline zone	Elevated zone [c]
		Shallow	Deep[b]			
Winter-Spring	1.90	2.65	1.90	2.91	0.86	1.90
Summer-Autumn	4.15	3.76	4.15	1.59	1.14[a]	4.15
Autumn-Winter	2.39[a]	2.78[a]	2.39	9.14	1.70	2.39

[a] No GHG emission measurements have been conducted in the cropping season. The average value of EF measured from other cropping seasons on the same zone is adapted; [b]Acid sulphate soil in the MRD with only deep (>50cm) sulfidic materials; [c]No GHG emission measurements have been conducted in the zone. EFs in alluvial zone are adapted.

Table 2. Estimated seasonal methane emission factor of the MRD provinces (2015-2016)

Province	Area-weighted emission factor per province (kg/ha/day)		
	Winter-spring	Summer-autumn	Autumn-winter
An Giang	2.65	2.30	7.60
Bac Lieu	1.25	2.11	1.90
Ben Tre	1.08	2.77	1.91
Can Tho	1.94	4.02	2.58
Ca Mau	1.21	3.37	1.96
Dong Thap	2.65	1.91	7.70
Hau Giang	2.03	4.08	2.47
Kien Giang	2.02	3.69	2.71
Long An	2.51	1.73	4.35
Soc Trang	1.38	3.14	2.02
Tien Giang	2.06	3.32	3.34
Tra Vinh	1.50	3.15	2.14
Vinh Long	2.15	4.00	2.53

Conclusion and future research

The data used in this analysis were based on measurements conducted during the CLUES project (2011-2015) described in Vo et al. (2018). In turn, the data base only represents a 'snapshot' corresponding to the information available by the time of publishing the info note, that is, mid-2019. This data base will need to be updated once additional GHG data become available. Due to the nature of this calculation, these EFs will undergo some inter-annual variations because the areas planted with rice may vary on a yearly basis. Regardless of these small uncertainties, the presented data on EF represented a good basis for calculating 'baseline emissions' in the MRD.

References

- Boschetti M, Busetto L, Manfron G, Laborte A, Asilo S, Pazhanivelan S, Nelson A. 2017. PhenoRice: A method for automatic extraction of spatio-temporal information on rice crops using satellite data time series.
- General Statistics Office (GSO). 2017. Statistical Yearbook of Vietnam. Hanoi, Vietnam: Statistical Publishing House.
- Ministry of Natural Resources and Environment (MoNRE). 2014. The Initial Biennial Updated Report of Viet Nam to the United Nations Framework Convention on Climate Change. Hanoi, Vietnam: Ministry of Natural Resources and Environment.
- Phong ND, Wassmann R, Tri LQ, Hien NX, Lang NT, Hoa LV, Nhan DK, Trung NH, Phung CV. 2016. Final Report for SMCN/2009/021: Climate change affecting land use in the Mekong Delta: Adaptation of rice-based cropping systems (CLUES). Canberra, Australia: Australian Center for International Agricultural Research.
- Servir Mekong. 2019. Land cover maps (2015-2017). SERVIR-Mekong project.
- Ton TC, Tran AP, Nguyen CP, Nguyen VN, Khanh PQ. 1989. Soil map of the Mekong Delta at scale of 1:250,000. Hanoi, Vietnam: National Institute of Agricultural Planning and Projection (NIAPP).
- Vo TBT, Wassmann R, Tirol-Padre A, Cao VP, MacDonald B, Espaldon MVO, Sander BO. 2018. Methane emission from rice cultivation in different agro-ecological zones of the Mekong River Delta: seasonal patterns and emission factors for baseline water management. Soil Science and Plant Nutrition 64, 47-58, DOI: 10.1080/00380768.2017.1413926.
- Wassmann R, Aulakh MS. 2000. The role of rice plants in regulating mechanisms of methane missions. Biology and Fertility of Soils 31, 20-29.
- Wassmann R, Phong ND, Tho TQ, Hoanh CT, Khoi, NH, Hien NX, Vo TBT, Tuong TP. 2019. High-resolution mapping of flood and salinity risks for rice production in the Vietnamese Mekong Delta. Field Crops Research 236, 111-120.

This document summarizes the findings of several studies on the variation of rice cultivation land and methane emission from irrigated rice fields, which were supported by the Climate and Clean Air Coalition (CCAC), Australian Centre for International Agricultural Research (ACIAR), and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

The intent of this brief is to provide additional explanation and information to the scientific article of Vo et al. (2018) and to use their findings for GHG estimations and calculations to guide low-emissions investments and mitigation strategies in the MRD.

Bui Tan Yen *(y.bui@irri.org) is an IRRI researcher based in Vietnam, specializing in soil science, geographic information system, and modeling.*

Reiner Wassmann *(R.Wassmann@irri.org) is climate change specialist working at IRRI in its headquarter in the Philippines.*

Bjoern Ole Sander *(b.sander@irri.org) is the IRRI Representative in Vietnam, specializing in climate change mitigation and adaptation in rice production systems.*

The views expressed in this brief are those of the authors and are not necessarily endorsed by or representative of IRRI or of the co-sponsoring or supporting organizations.

Research led by: IRRI