การจัดการฟาร์มกับการปล่อยก๊าซเรือนกระจกในนาข้าว: กรณีศึกษา จ. ศรีสะเกษ

ส่วนวิจัยเศรษฐกิจทรัพยากรการเกษตร

สำนักวิจัยเศรษฐกิจการเกษตร

นำเสนอโดย

ดร.อัครพล ฮวบเจริญ (เศรษฐกรปฏิบัติการ)

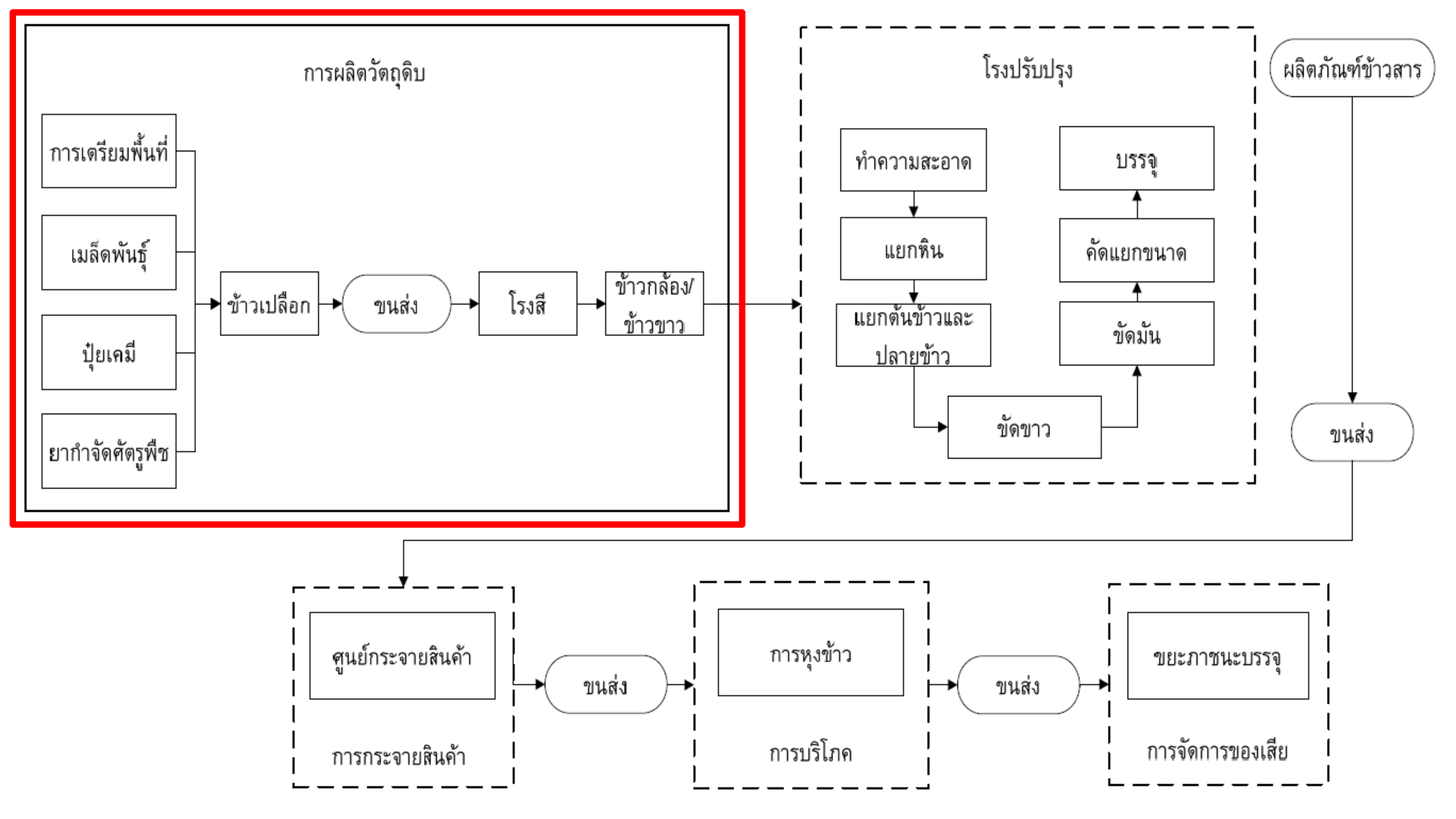
การสัมมนาเชิงปฏิบัติการ เรื่อง

“ผลการดำเนินงานโครงการคาร์บอนฟุตพริ้นท์ผลิตภัณฑ์เกษตร”

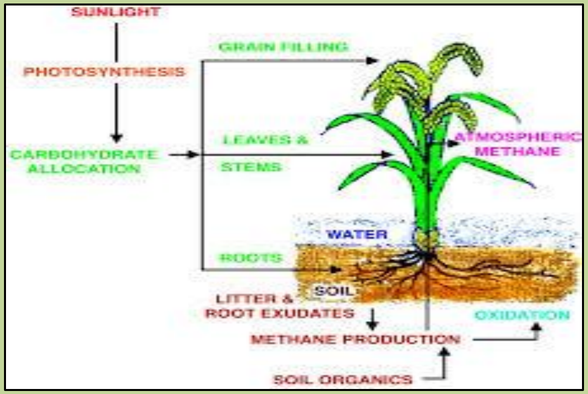
วันที่ 15 กันยายน 2557

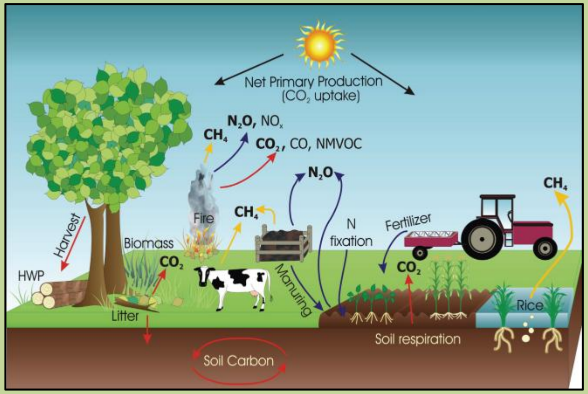
1. แนวคิดและทฤษฎี

แผนผังวัฏจักรชีวิตของผลิตภัณฑ์ข้าวสาร:

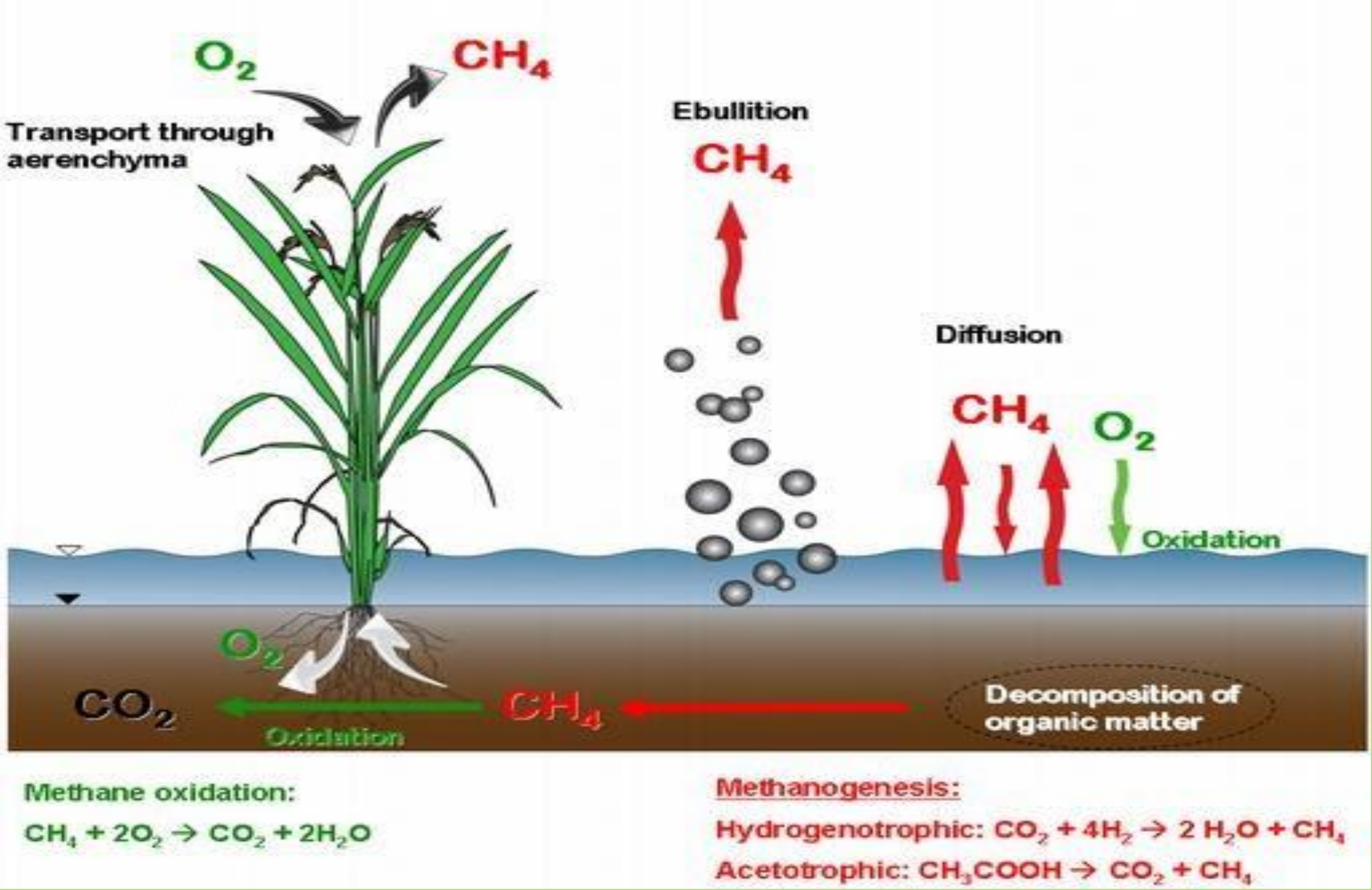


2. แหล่งปล่อยก๊าซเรือนกระจกหลักของการปลูกข้าวเปลือก





2.1 การปล่อยก๊าซมีเทน (CH_4) จากนาข้าว



IPCC 2006: การประเมินมีเทนจากนาข้าว

EQUATION 5.1

CH_4 EMISSIONS FROM RICE CULTIVATION

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

Where:

$CH_{4\ Rice}$ = annual methane emissions from rice cultivation, Gg CH_4 yr^{-1}

EF_{ijk} = a daily emission factor for *i*, *j*, and *k* conditions, kg CH_4 ha^{-1} day^{-1}

t_{ijk} = cultivation period of rice for *i*, *j*, and *k* conditions, day

A_{ijk} = annual harvested area of rice for *i*, *j*, and *k* conditions, ha yr^{-1}

i, *j*, and *k* = represent different ecosystems, water regimes, type and amount of organic amendments, and other conditions under which CH_4 emissions from rice may vary

IPCC 2006: การประเมินมีเทนจากนาข้าว (ต่อ)

TABLE 5.11
DEFAULT CH_4 BASELINE EMISSION FACTOR ASSUMING NO FLOODING FOR LESS THAN 180 DAYS PRIOR TO RICE CULTIVATION, AND CONTINUOUSLY FLOODED DURING RICE CULTIVATION WITHOUT ORGANIC AMENDMENTS

	Emission factor	Error range
CH_4 emission (kg CH_4 ha^{-1} d^{-1})	1.30	0.80 - 2.20

Source: Yan et al., 2005

EQUATION 5.2
ADJUSTED DAILY EMISSION FACTOR

$$EF_i = EF_c \bullet SF_w \bullet SF_p \bullet SF_o \bullet SF_{s,r}$$

Where:

EF_i = adjusted daily emission factor for a particular harvested area

EF_c = baseline emission factor for continuously flooded fields without organic amendments

SF_w = scaling factor to account for the differences in water regime during the cultivation period (from Table 5.12)

SF_p = scaling factor to account for the differences in water regime in the pre-season before the cultivation period (from Table 5.13)

SF_o = scaling factor should vary for both type and amount of organic amendment applied (from Equation 5.3 and Table 5.14)

$SF_{s,r}$ = scaling factor for soil type, rice cultivar, etc., if available

IPCC 2006: การประเมินมีเทนจากนาข้าว (ต่อ)

TABLE 5.12
DEFAULT CH_4 EMISSION SCALING FACTORS FOR WATER REGIMES DURING THE CULTIVATION PERIOD RELATIVE TO CONTINUOUSLY FLOODED FIELDS

Water regime		Aggregated case: Scaling factor (SF_w)	Aggregated case: Error range	Disaggregated case: Scaling factor (SF_w)	Disaggregated case: Error range
Upland [a]		0	-	0	-
Irrigated [b]	Continuously flooded	0.78	0.62 - 0.98	1	0.79 - 1.26
	Intermittently flooded – single aeration			0.60	0.46 - 0.80
	Intermittently flooded – multiple aeration			0.52	0.41 - 0.66
Rainfed and deep water [c]	Regular rainfed	0.27	0.21 - 0.34	0.28	0.21 - 0.37
	Drought prone			0.25	0.18 - 0.36
	Deep water			0.31	ND

ND: not determined

[a] Fields are never flooded for a significant period of time.

[b] Fields are flooded for a significant period of time and water regime is fully controlled.

- Continuously flooded: Fields have standing water throughout the rice growing season and may only dry out for harvest (end-season drainage).
- Intermittently flooded : Fields have at least one aeration period of more than 3 days during the cropping season.
  - Single aeration: Fields have a single aeration during the cropping season at any growth stage (except for end-season drainage).
  - Multiple aeration: Fields have more than one aeration period during the cropping season (except for end-season drainage).

[c] Fields are flooded for a significant period of time and water regime depends solely on precipitation.

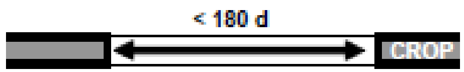
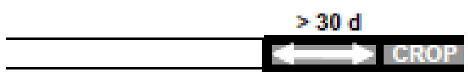
- Regular rainfed: The water level may rise up to 50 cm during the cropping season.
- Drought prone: Drought periods occur during every cropping season.
- Deep water rice: Floodwater rises to more than 50 cm for a significant period of time during the cropping season.

Note: Other rice ecosystem categories, like swamps and inland, saline or tidal wetlands may be discriminated within each sub-category.

Source: Yan *et al.*, 2005

IPCC 2006: การประเมินมีเทนจากนาข้าว (ต่อ)

TABLE 5.13
DEFAULT CH_4 EMISSION SCALING FACTORS FOR WATER REGIMES BEFORE THE CULTIVATION PERIOD

Water regime prior to rice cultivation (schematic presentation showing flooded periods as shaded)	Aggregated case		Disaggregated case	
	Scaling factor (SF_p)	Error range	Scaling factor (SF_p)	Error range
Non flooded pre-season <180 d 			1	0.88 - 1.14
Non flooded pre-season >180 d 	1.22	1.07 - 1.40	0.68	0.58 - 0.80
Flooded pre-season (>30 d)[a,b] 			1.90	1.65 - 2.18

[a] Short pre-season flooding periods of less than 30 d are not considered in selection of SFp

[b] For calculation of pre-season emission see below (section on completeness)

Source: Yan *et al.*, 2005

IPCC 2006: การประเมินมีเทนจากนาข้าว (ต่อ)

EQUATION 5.3
ADJUSTED CH_4 EMISSION SCALING FACTORS FOR ORGANIC AMENDMENTS

$$SF_o = \left(1 + \sum_i ROA_i \bullet CFOA_i\right)^{0.59}$$

Where:

SF_o = scaling factor for both type and amount of organic amendment applied

ROA_i = application rate of organic amendment *i*, in dry weight for straw and fresh weight for others, tonne ha^{-1}

$CFOA_i$ = conversion factor for organic amendment *i* (in terms of its relative effect with respect to straw applied shortly before cultivation) as shown in Table 5.14.

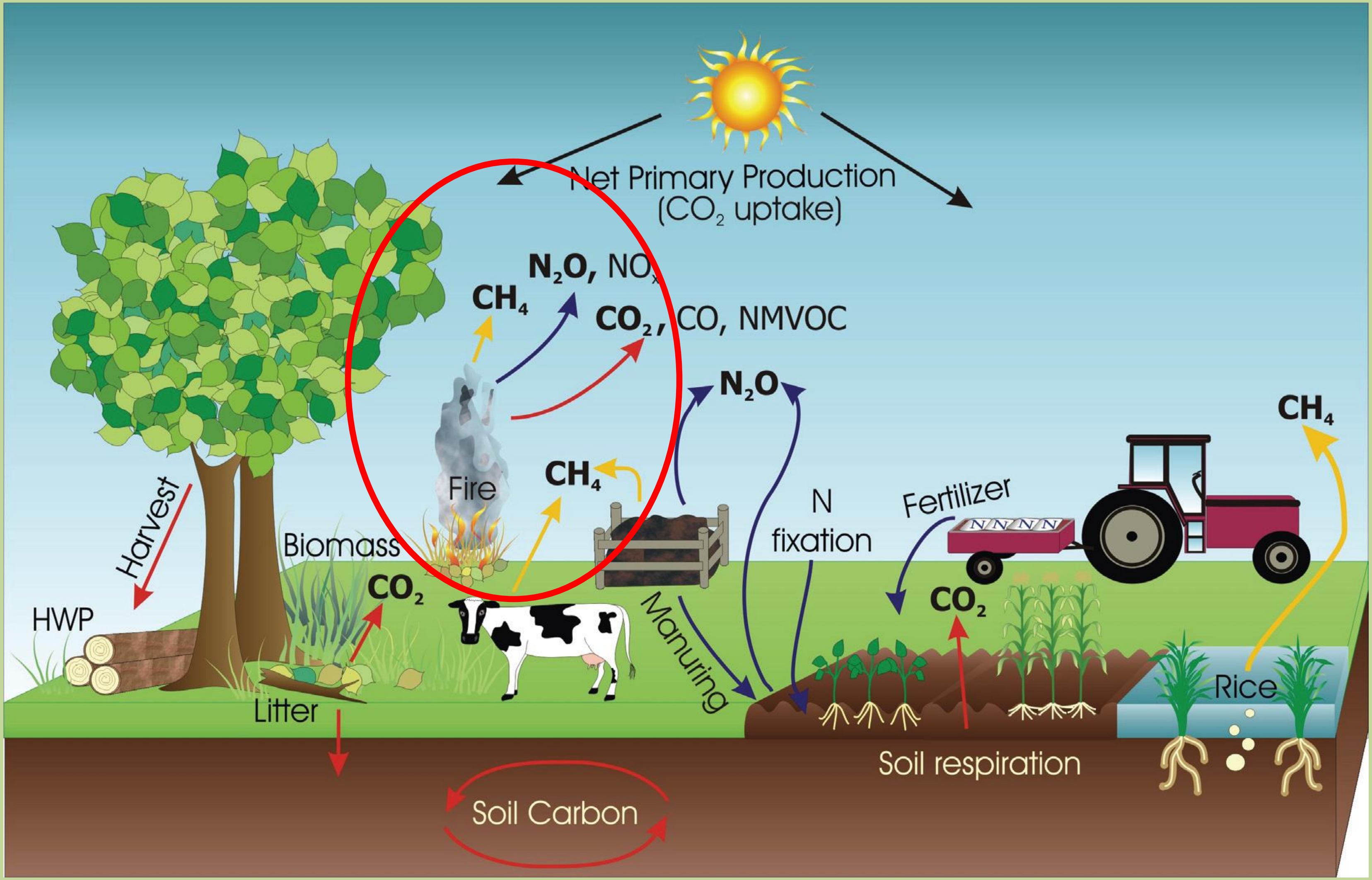
TABLE 5.14
DEFAULT CONVERSION FACTOR FOR DIFFERENT TYPES OF ORGANIC AMENDMENT

Organic amendment	Conversion factor (CFOA)	Error range
Straw incorporated shortly (<30 days) before cultivation[a]	1	0.97 - 1.04
Straw incorporated long (>30 days) before cultivation[a]	0.29	0.20 - 0.40
Compost	0.05	0.01 - 0.08
Farm yard manure	0.14	0.07 - 0.20
Green manure	0.50	0.30 - 0.60

[a] Straw application means that straw is incorporated into the soil, it does not include case that straw just placed on the soil surface, nor that straw was burnt on the field.

Source: Yan *et al*., 2005

2.2 การเผาชีวมวลหลังเก็บเกี่ยว: CH_4 N_2O CO และ NO_x



2.2 การเผาชีวมวลหลังเก็บเกี่ยว: CH_4 N_2O CO และ NO_x (ต่อ)

EQUATION 2.27
ESTIMATION OF GREENHOUSE GAS EMISSIONS FROM FIRE

$$L_{fire} = A \bullet M_B \bullet C_f \bullet G_{ef} \bullet 10^{-3}$$

Where:

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CH_4, N_2O, etc.

A = area burnt, ha

M_B = mass of fuel available for combustion, tonnes ha^{-1}. This includes biomass, ground litter and dead wood. When Tier 1 methods are used then litter and dead wood pools are assumed zero, except where there is a land-use change (see Section 2.3.2.2).

C_f = combustion factor, dimensionless (default values in Table 2.6)

G_{ef} = emission factor, g kg^{-1} dry matter burnt (default values in Table 2.5)

Note: Where data for M_B and C_f are not available, a default value for the amount of fuel actually burnt (the product of M_B and C_f) can be used (Table 2.4) under Tier 1 methodology.

2.2 การเผาชีวมวลหลังเก็บเกี่ยว: CH_4 N_2O CO และ NO_x (ต่อ)

TABLE 2.5
EMISSION FACTORS (g kg^{-1} DRY MATTER BURNT) FOR VARIOUS TYPES OF BURNING. VALUES ARE MEANS ± SD AND ARE BASED ON THE COMPREHENSIVE REVIEW BY ANDREAE AND MERLET (2001)
(To be used as quantity 'G_{ef}' in Equation 2.27)

Category	CO_2	CO	CH_4	N_2O	NO_X
Savanna and grassland	1613 ± 95	65 ± 20	2.3 ± 0.9	0.21 ± 0.10	3.9 ± 2.4
Agricultural residues	1515 ± 177	92 ± 84	2.7	0.07	2.5 ± 1.0
Tropical forest	1580 ± 90	104 ± 20	6.8 ± 2.0	0.20	1.6 ± 0.7
Extra tropical forest	1569 ± 131	107 ± 37	4.7 ± 1.9	0.26 ±0.07	3.0 ± 1.4
Biofuel burning	1550 ± 95	78 ± 31	6.1 ± 2.2	0.06	1.1 ± 0.6

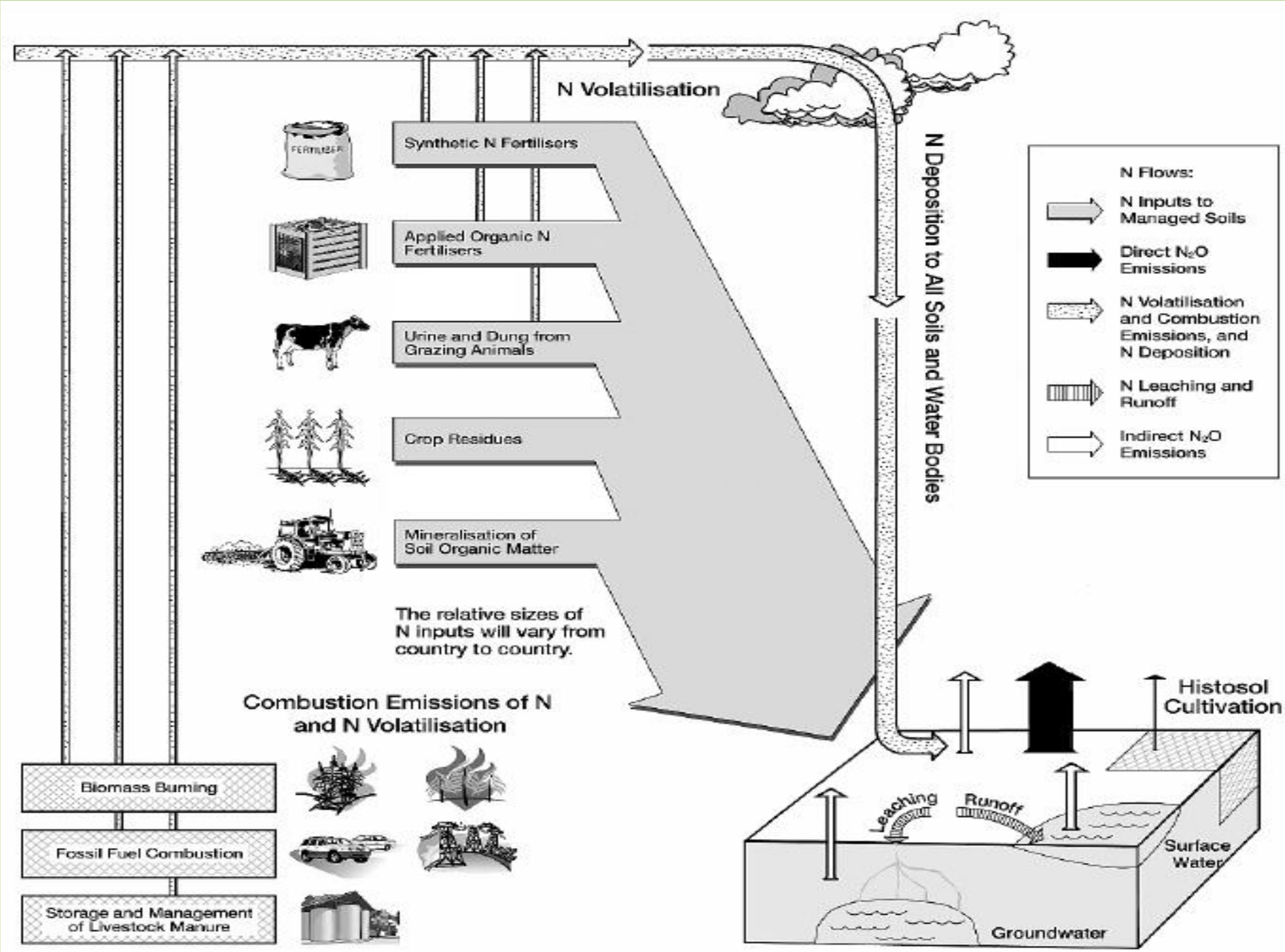
Note: The "extra tropical forest' category includes all other forest types.
Note: For combustion of non-woody biomass in Grassland and Cropland, CO_2 emissions do not need to be estimated and reported, because it is assumed that annual CO_2 removals (through growth) and emissions (whether by decay or fire) by biomass are in balance (see earlier discussion on synchrony in Section 2.4.

TABLE 2.6
COMBUSTION FACTOR VALUES (PROPORTION OF PREFIRE FUEL BIOMASS CONSUMED) FOR FIRES IN A RANGE OF VEGETATION TYPES
(Values in column 'mean' are to be used for quantity C_f in Equation 2.27)

Vegetation type	Subcategory	Mean	SD	References
Agricultural residues (Post harvest field burning)	Wheat residues	0.90	-	see Note b
	Maize residues	0.80	-	see Note b
	Rice residues	0.80	-	see Note b
	Sugarcane [a]	0.80	-	see Note b

[*] Surface layer combustion only
[~] Derived from slashed tropical forest (includes unburned woody material)
[a] For sugarcane, data refer to burning before harvest of the crop.
[b] Expert assessment by authors.

2.3 การใช้ปุ๋ยเคมีและปุ๋ยอินทรีย์: N_2O from Managed Soil



2.3 การใช้ปุ๋ยเคมีและปุ๋ยอินทรีย์: N_2O from Managed Soil (ต่อ)

EQUATION 11.1

DIRECT N_2O EMISSIONS FROM MANAGED SOILS (TIER 1)

$$N_2O_{Direct}–N = N_2O–N_{N\ inputs} + N_2O–N_{OS} + N_2O–N_{PRP}$$

Where:

$$N_2O–N_{N\ inputs} = \begin{bmatrix} \left[(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \bullet EF_1\right] + \\ \left[(F_{SN} + F_{ON} + F_{CR} + F_{SOM})_{FR} \bullet EF_{1FR}\right] \end{bmatrix}$$

$$N_2O–N_{OS} = \begin{bmatrix} (F_{OS,CG,Temp} \bullet EF_{2CG,Temp}) + (F_{OS,CG,Trop} \bullet EF_{2CG,Trop}) + \\ (F_{OS,F,Temp,NR} \bullet EF_{2F,Temp,NR}) + (F_{OS,F,Temp,NP} \bullet EF_{2F,Temp,NP}) + \\ (F_{OS,F,Trop} \bullet EF_{2F,Trop}) \end{bmatrix}$$

$$N_2O–N_{PRP} = \left[(F_{PRP,CPP} \bullet EF_{3PRP,CPP}) + (F_{PRP,SO} \bullet EF_{3PRP,SO})\right]$$

Where:

$N_2O_{Direct}–N$ = annual direct $N_2O–N$ emissions produced from managed soils, kg $N_2O–N$ yr^{-1}

$N_2O–N_{N\ inputs}$ = annual direct $N_2O–N$ emissions from N inputs to managed soils, kg $N_2O–N$ yr^{-1}

$N_2O–N_{OS}$ = annual direct $N_2O–N$ emissions from managed organic soils, kg $N_2O–N$ yr^{-1}

$N_2O–N_{PRP}$ = annual direct $N_2O–N$ emissions from urine and dung inputs to grazed soils, kg $N_2O–N$ yr^{-1}

F_{SN} = annual amount of synthetic fertiliser N applied to soils, kg N yr^{-1}

F_{ON} = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils (Note: If including sewage sludge, cross-check with Waste Sector to ensure there is no double counting of N_2O emissions from the N in sewage sludge), kg N yr^{-1}

F_{CR} = annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N yr^{-1}

F_{SOM} = annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N yr^{-1}

F_{OS} = annual area of managed/drained organic soils, ha (Note: the subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively)

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1} (Note: the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)

EF_1 = emission factor for N_2O emissions from N inputs, kg $N_2O–N$ (kg N input)$^{-1}$ (Table 11.1)

EF_{1FR} is the emission factor for N_2O emissions from N inputs to flooded rice, kg $N_2O–N$ (kg N input)$^{-1}$ (Table 11.1) [5]

EF_2 = emission factor for N_2O emissions from drained/managed organic soils, kg $N_2O–N$ ha^{-1} yr^{-1}; (Table 11.1) (Note: the subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively)

EF_{3PRP} = emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg $N_2O–N$ (kg N input)$^{-1}$; (Table 11.1) (Note: the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)

TABLE 11.1

DEFAULT EMISSION FACTORS TO ESTIMATE DIRECT N_2O EMISSIONS FROM MANAGED SOILS

Emission factor	Default value	Uncertainty range
EF_1 for N additions from mineral fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon [kg $N_2O–N$ (kg N)$^{-1}$]	0.01	0.003 - 0.03
EF_{1FR} for flooded rice fields [kg $N_2O–N$ (kg N)$^{-1}$]	0.003	0.000 - 0.006
$EF_{2CG,Temp}$ for temperate organic crop and grassland soils (kg $N_2O–N$ ha^{-1})	8	2 - 24
$EF_{2CG,Trop}$ for tropical organic crop and grassland soils (kg $N_2O–N$ ha^{-1})	16	5 - 48
$EF_{2F,Temp,Org,R}$ for temperate and boreal organic nutrient rich forest soils (kg $N_2O–N$ ha^{-1})	0.6	0.16 - 2.4
$EF_{2F,Temp,Org,P}$ for temperate and boreal organic nutrient poor forest soils (kg $N_2O–N$ ha^{-1})	0.1	0.02 - 0.3
$EF_{2F,Trop}$ for tropical organic forest soils (kg $N_2O–N$ ha^{-1})	8	0 - 24
$EF_{3PRP,CPP}$ for cattle (dairy, non-dairy and buffalo), poultry and pigs [kg $N_2O–N$ (kg N)$^{-1}$]	0.02	0.007 - 0.06
$EF_{3PRP,SO}$ for sheep and 'other animals' [kg $N_2O–N$ (kg N)$^{-1}$]	0.01	0.003 - 0.03

Sources:

EF_1: Bouwman et al. 2002a,b; Stehfest & Bouwman, 2006; Novoa & Tejeda, 2006 in press; EF_{1FR}: Akiyama *et al.*, 2005; $EF_{2CG,Temp}$, $EF_{2CG,Trop}$, $EF_{2F,Trop}$: Klemedtsson *et al.*, 1999, IPCC Good Practice Guidance, 2000; $EF_{2F,Temp}$: Alm *et al.*, 1999; Laine *et al.*, 1996; Martikainen *et al.*, 1995; Minkkinen *et al.*, 2002; Regina *et al.*, 1996; Klemedtsson *et al.*, 2002; $EF_{3,CPP}$, $EF_{3,SO}$: de Klein, 2004.

2.3 การใช้ปุ๋ยเคมีและปุ๋ยอินทรีย์: N_2O from Managed Soil (ต่อ)

EQUATION 11.3
N FROM ORGANIC N ADDITIONS APPLIED TO SOILS (TIER 1)

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$$

Where:

F_{ON} = total annual amount of organic N fertiliser applied to soils other than by grazing animals, kg N yr^{-1}

F_{AM} = annual amount of animal manure N applied to soils, kg N yr^{-1}

F_{SEW} = annual amount of total sewage N (coordinate with Waste sector to ensure that sewage N is not double-counted) that is applied to soils, kg N yr^{-1}

F_{COMP} = annual amount of total compost N applied to soils (ensure that manure N in compost is not double-counted), kg N yr^{-1}

F_{OOA} = annual amount of other organic amendments used as fertiliser (e.g., rendering waste, guano, brewery waste, etc.), kg N yr^{-1}

2.3 การใช้ปุ๋ยเคมีและปุ๋ยอินทรีย์: N_2O from Managed Soil (ต่อ)

EQUATION 11.9

N_2O FROM ATMOSPHERIC DEPOSITION OF N VOLATILISED FROM MANAGED SOILS (TIER 1)

$$N_2O_{(ATD)}-N = \left[\left(F_{SN} \bullet Frac_{GASF} \right) + \left(\left(F_{ON} + F_{PRP} \right) \bullet Frac_{GASM} \right) \right] \bullet EF_4$$

Where:

$N_2O_{(ATD)}-N$ = annual amount of N_2O-N produced from atmospheric deposition of N volatilised from managed soils, kg N_2O-N yr^{-1}

F_{SN} = annual amount of synthetic fertiliser N applied to soils, kg N yr^{-1}

$Frac_{GASF}$ = fraction of synthetic fertiliser N that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied)$^{-1}$ (Table 11.3)

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1}

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1}

$Frac_{GASM}$ = fraction of applied organic N fertiliser materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied or deposited)$^{-1}$ (Table 11.3)

EF_4 = emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg $N-N_2O$ (kg NH_3-N + NO_x-N volatilised)$^{-1}$] (Table 11.3)

2.3 การใช้ปุ๋ยเคมีและปุ๋ยอินทรีย์: N2O from Managed Soil (ต่อ)

EQUATION 11.10
N_2O FROM N LEACHING/RUNOFF FROM MANAGED SOILS IN REGIONS WHERE LEACHING/RUNOFF OCCURS (TIER 1)

$$N_2O_{(L)}\text{–}N = \left(F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}\right) \bullet Frac_{LEACH-(H)} \bullet EF_5$$

Where:

$N_2O_{(L)}$–N = annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs, kg N_2O–N yr^{-1}

F_{SN} = annual amount of synthetic fertiliser N applied to soils in regions where leaching/runoff occurs, kg N yr^{-1}

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils in regions where leaching/runoff occurs, kg N yr^{-1}

F_{PRP} = annual amount of urine and dung N deposited by grazing animals in regions where leaching/runoff occurs, kg N yr^{-1} (from Equation 11.5)

F_{CR} = amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs, kg N yr^{-1}

F_{SOM} = annual amount of N mineralised in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management in regions where leaching/runoff occurs, kg N yr^{-1} (from Equation 11.8)

$Frac_{LEACH-(H)}$ = fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N (kg of N additions)$^{-1}$ (Table 11.3)

EF_5 = emission factor for N_2O emissions from N leaching and runoff, kg N_2O–N (kg N leached and runoff)$^{-1}$ (Table 11.3)

2.3 การใช้ปุ๋ยเคมีและปุ๋ยอินทรีย์: N_2O from Managed Soil (ต่อ)

TABLE 11.3
DEFAULT EMISSION, VOLATILISATION AND LEACHING FACTORS FOR INDIRECT SOIL N_2O EMISSIONS

Factor	Default value	Uncertainty range
EF_4 [N volatilisation and re-deposition], kg N_2O–N (kg NH_3–N + NO_X–N volatilised)$^{-1}$ [22]	0.010	0.002 - 0.05
EF_5 [leaching/runoff], kg N_2O–N (kg N leaching/runoff)$^{-1}$ [23]	0.0075	0.0005 - 0.025
$Frac_{GASF}$ [Volatilisation from synthetic fertiliser], (kg NH_3–N + NO_x–N) (kg N applied)$^{-1}$	0.10	0.03 - 0.3
$Frac_{GASM}$ [Volatilisation from all organic N fertilisers applied , and dung and urine deposited by grazing animals], (kg NH_3–N + NO_x–N) (kg N applied or deposited)$^{-1}$	0.20	0.05 - 0.5
$Frac_{LEACH-(H)}$ [N losses by leaching/runoff for regions where Σ(rain in rainy season) - Σ (PE in same period) > soil water holding capacity, OR where irrigation (except drip irrigation) is employed], kg N (kg N additions or deposition by grazing animals)$^{-1}$	0.30	0.1 - 0.8

Note: The term $Frac_{LEACH}$ previously used has been modified so that it now only applies to regions where soil water-holding capacity is exceeded, as a result of rainfall and/or irrigation (excluding drip irrigation), and leaching/runoff occurs, and redesignated as $Frac_{LEACH-(H)}$. In the definition of $Frac_{LEACH-(H)}$ above, PE is potential evaporation, and the rainy season(s) can be taken as the period(s) when rainfall > 0.5 * Pan Evaporation. (Explanations of potential and pan evaporation are available in standard meteorological and agricultural texts). For other regions the default $Frac_{LEACH}$ is taken as zero.

2.4 การใช้ปูนขาวและปุ๋ยยูเรีย: CO_2

EQUATION 11.13
ANNUAL CO_2 EMISSIONS FROM UREA APPLICATION

$$CO_2\text{–}C\ Emission = M \bullet EF$$

Where:

CO_2–C Emission = annual C emissions from urea application, tonnes C yr^{-1}

M = annual amount of urea fertilisation, tonnes urea yr^{-1}

EF = emission factor, tonne of C (tonne of urea)$^{-1}$

EQUATION 11.12
ANNUAL CO_2 EMISSIONS FROM LIME APPLICATION

$$CO_2\text{–}C\ Emission = (M_{Limestone} \bullet EF_{Limestone}) + (M_{Dolomite} \bullet EF_{Dolomite})$$

Where:

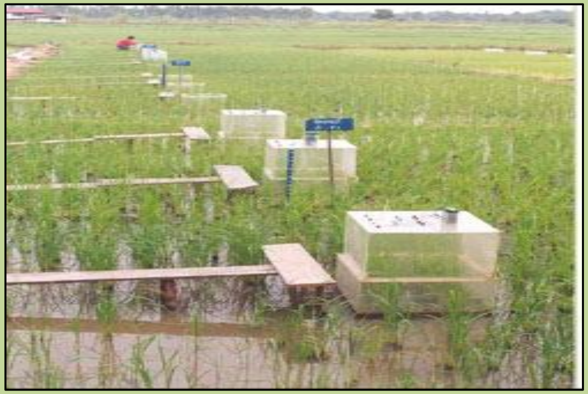
CO_2–C Emission = annual C emissions from lime application, tonnes C yr^{-1}

M = annual amount of calcic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$), tonnes yr^{-1}

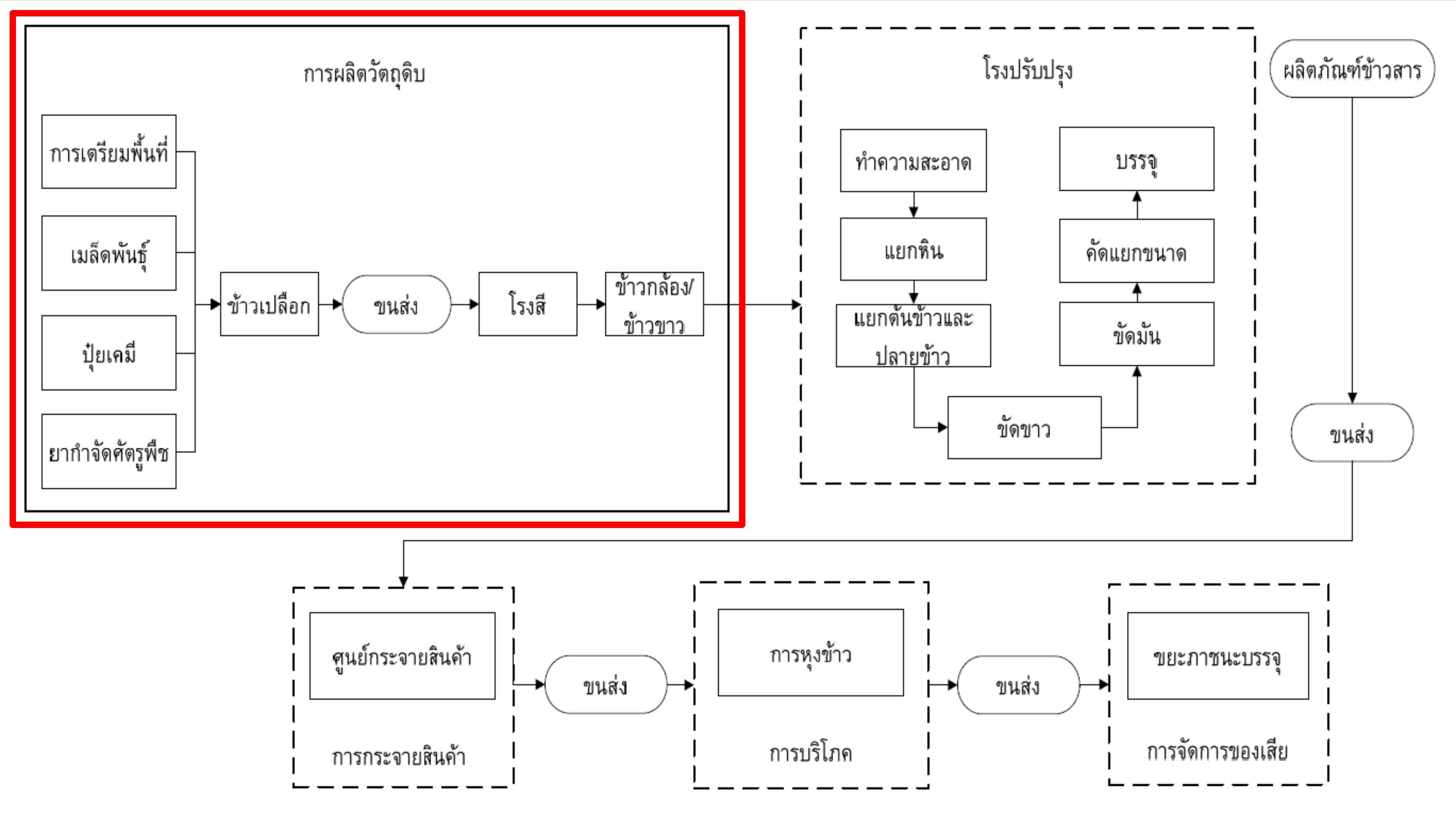
EF = emission factor, tonne of C (tonne of limestone or dolomite)$^{-1}$

EF_{Urea} = 0.2 tonne of C (tonne of urea)^-1
$EF_{Limestone}$ = 0.12 tonne of C (tonne of limestone)^-1
$EF_{Dolomite}$ = 0.13 tonne of C (tonne of Dolomite)^-1

3.ผลการประเมินการปล่อยก๊าซเรือนกระจกในนาข้าว: กรณีศึกษา จ.ศรีสะเกษ



แผนผังวัฏจักรชีวิตของผลิตภัณฑ์ข้าวสาร:



ตารางที่ 1 การปล่อยก๊าซเรือนกระจก (IPCC 2006)

Table 1: Total Emission (IPCC 2006)

IPCC 2006: Total Emission (Kg CO2-e)	I. CH4 Rice Cultivation		II. CO2 Biomass Burning	III. N2O Fertilizer and Organic matters (Managed Soil)			
Detail:	JGSEE	IPCC	IPCC	Direct	Volatilisation	Leaching/Runoff	IPCC: Managed Soil
Emission Amount	1,001,590.33	995,802.29	593.25	33,497.73	12,801.15	25,123.30	71,422.17
Percent		91.37	0.05	46.90	17.92	35.18	6.55
Emission/area (Rai)	367.96	365.83	0.22	12.31	4.70	9.23	26.24
Emission 1Kg Paddy	1.00	0.99	0.00	0.03	0.01	0.02	0.07

IPCC 2006: Total Emissi	IV. CO2 Lime&Urea	V. Total Emission	
Detail:	Lime&Urea	JGSEE	IPCC
Emission Amount	22,066.00	1,095,671.75	1,089,883.72
Percent	2.02		100.00
Emission/area (Rai)	8.11	402.52	400.40
Emission 1Kg Paddy	0.02	1.09	1.08

4.วีธีการประเมิน: การศึกษาเปรียบเทียบ

IPCC 2006 และ IPCC 1996 Guidelines

ตารางที่ 1 และ 2 การปล่อยก๊าซเรือนกระจก (IPCC 2006 และ IPCC 1996)

Table 1: Total Emission (IPCC 2006)

IPCC 2006: Total Emission (Kg CO2-e)	I. CH4 Rice Cultivation		II. CO2 Biomass Burning	III. N2O Fertilizer and Organic matters (Managed Soil)			
Detail:	JGSEE	IPCC	IPCC	Direct	Volatilisation	Leaching/Runoff	IPCC: Managed Soil
Emission Amount	1,001,590.33	995,802.29	593.25	33,497.73	12,801.15	25,123.30	71,422.17
Percent		91.37	0.05	46.90	17.92	35.18	6.55
Emission/area (Rai)	367.96	365.83	0.22	12.31	4.70	9.23	26.24
Emission 1Kg Paddy	1.00	0.99	0.00	0.03	0.01	0.02	0.07

IPCC 2006: Total Emissi	IV. CO2 Lime&Urea	V. Total Emission	
Detail:	Lime&Urea	JGSEE	IPCC
Emission Amount	22,066.00	1,095,671.75	1,089,883.72
Percent	2.02		100.00
Emission/area (Rai)	8.11	402.52	400.40
Emission 1Kg Paddy	0.02	1.09	1.08

Table 2: Total Emission (IPCC 1996)

IPCC 1996: Total Emission (Kg CO2-e)	I. CH4 Rice Cultivation		II. CO2 Biomass Burning	III. N2O Fertilizer and Organic matters (Managed Soil)			
Detail:	JGSEE	IPCC	IPCC	Direct	Volatilisation	Leaching/Runoff	IPCC: Managed Soil
Emission Amount	2,646,570.58	1,508,913.12	3,224.82	139,573.87	12,801.15	50,246.59	202,621.61
Percent		88.00	0.19	68.88	6.32	24.80	11.82
Emission/area (Rai)	972.29	554.34	1.18	51.28	4.70	18.46	74.44
Emission 1Kg Paddy	2.63	1.50	0.00	0.14	0.01	0.05	0.20

IPCC 1996: Total Emissi	IV. CO2 Lime&Urea	V. Total Emission	
Detail:	Lime&Urea	JGSEE	IPCC
Emission Amount	-	2,852,417.01	1,714,759.55
Percent	-		100.00
Emission/area (Rai)	-	1,047.91	629.96
Emission 1Kg Paddy	-	2.84	1.70

ANOVA Test: Analysis Of Variance between groups

```
. anova  IPCCtotalRai  IPCCMethod

                        Number of obs =      558     R-squared     =  0.1550
                        Root MSE      =   280.19     Adj R-squared =  0.1534
```

Source	Partial SS	df	MS	F	Prob > F
Model	8004153.05	1	8004153.05	101.96	0.0000
IPCCMethod	8004153.05	1	8004153.05	101.96	0.0000
Residual	43649548.5	556	78506.3821		
Total	51653701.5	557	92735.5503		

```
. anova  IPCCtotalKgPaddy  IPCCMethod

                        Number of obs =      558     R-squared     =  0.0882
                        Root MSE      = 1.29956     Adj R-squared =  0.0865
```

Source	Partial SS	df	MS	F	Prob > F
Model	90.7869666	1	90.7869666	53.76	0.0000
IPCCMethod	90.7869666	1	90.7869666	53.76	0.0000
Residual	939.011178	556	1.68886903		
Total	1029.79814	557	1.8488297		

5. การจัดการฟาร์ม: การศึกษาเปรียบเทียบระหว่าง นาข้าวอินทรีย์ นาข้าวเกษตรดีที่เหมาะสม (GAP) และ นาข้าวแบบดั้งเดิม

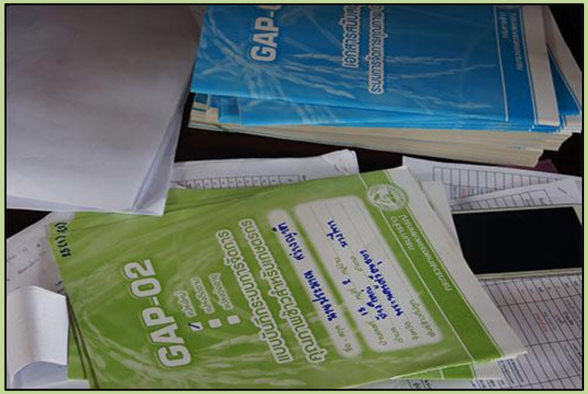


Table 3: Total Emission (Organic Farming, N=20)

IPCC 2006: Total Emission (Organic Farming, N=20)			
	I. CH4 Rice Cultivation		II. CO2 Biomass Burning
Detail:	JGSEE	IPCC	IPCC
Emission Amount	95,276.61	101,151.92	33.89
Percent		95.06	0.03
Emission/area (Rai)	566.28	601.20	0.20
Emission 1Kg Paddy	1.79	1.90	0.00

Table 4: Total Emission (GAP Farming, N=91)

IPCC 2006: Total Emission (GAP Farming, N=91)			
	I. CH4 Rice Cultivation		II. CO2 Biomass Burning
Detail:	JGSEE	IPCC	IPCC
Emission Amount	422,245.07	436,586.59	156.84
Percent		91.28	0.03
Emission/area (Rai)	444.23	459.32	0.17
Emission 1Kg Paddy	1.15	1.19	0.00

Table 5: Total Emission (Traditional Farming, N=168)

IPCC 2006: Total Emission (Traditional Farming, N=168)			
	I. CH4 Rice Cultivation		II. CO2 Biomass Burning
Detail:	JGSEE	IPCC	IPCC
Emission Amount	484,068.65	458,063.78	402.52
Percent		90.67	0.08
Emission/area (Rai)	301.93	285.71	0.25
Emission 1Kg Paddy	0.83	0.78	0.00

III. N2O Fertilizer and Organic matters (Managed Soil)				IV. CO2 Lime&Urea	V. Total Emission	
Direct	Volatilisation	Leaching/Runoff	IPCC: Managed Soil	Lime&Urea	JGSEE	IPCC
1,070.09	454.89	802.57	2,327.54	2,895.75	100,533.79	106,409.10
45.98	19.54	34.48	2.19	2.72		100.00
6.36	2.70	4.77	13.83	17.21	597.53	632.45
0.02	0.01	0.02	0.04	0.05	1.89	2.00

III. N2O Fertilizer and Organic matters (Managed Soil)				IV. CO2 Lime&Urea	V. Total Emission	
Direct	Volatilisation	Leaching/Runoff	IPCC: Managed Soil	Lime&Urea	JGSEE	IPCC
12,275.39	4,793.60	9,206.54	26,275.53	15,263.42	463,940.86	478,282.38
46.72	18.24	35.04	5.49	3.19		100.00
12.91	5.04	9.69	27.64	16.06	488.10	503.19
0.03	0.01	0.03	0.07	0.04	1.27	1.31

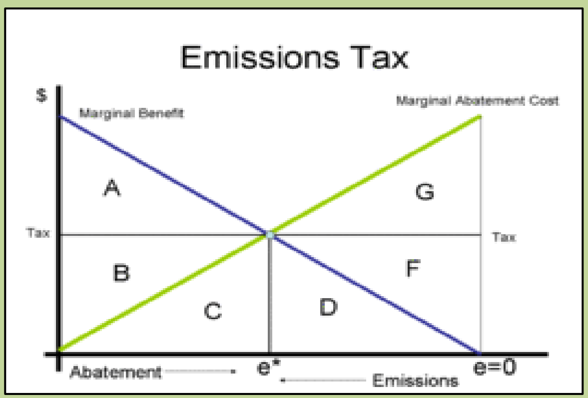
III. N2O Fertilizer and Organic matters (Managed Soil)				IV. CO2 Lime&Urea	V. Total Emission	
Direct	Volatilisation	Leaching/Runoff	IPCC: Managed Soil	Lime&Urea	JGSEE	IPCC
20,152.25	7,552.66	15,114.19	42,819.10	3,906.83	531,197.11	505,192.24
47.06	17.64	35.30	8.48	0.77		100.00
12.57	4.71	9.43	26.71	2.44	331.33	315.11
0.03	0.01	0.03	0.07	0.01	0.91	0.86

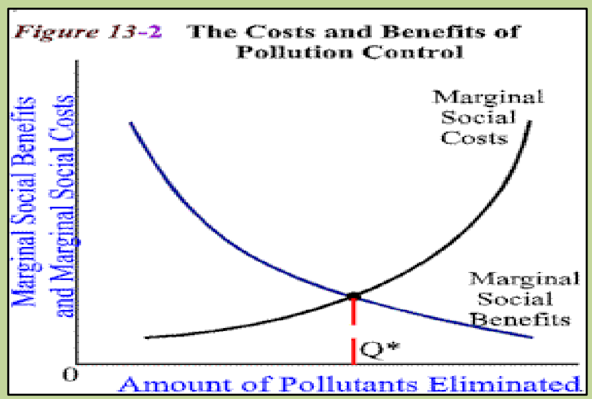
ANOVA Test: Analysis Of Variance between groups

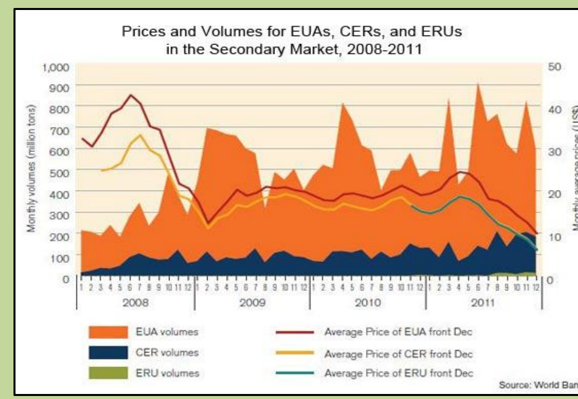
```
. anova  IPCCtotalRai farmsystem

                          Number of obs =      279     R-squared     =  0.0732
                          Root MSE      = 327.701     Adj R-squared =  0.0665

              Source |  Partial SS    df       MS           F     Prob > F
          -----------+----------------------------------------------------
               Model |  2341657.19     2   1170828.6      10.90     0.0000
                     |
          farmsystem |  2341657.19     2   1170828.6      10.90     0.0000
                     |
            Residual |  29639135.8   276  107388.173
          -----------+----------------------------------------------------
               Total |    31980793   278  115038.824
```

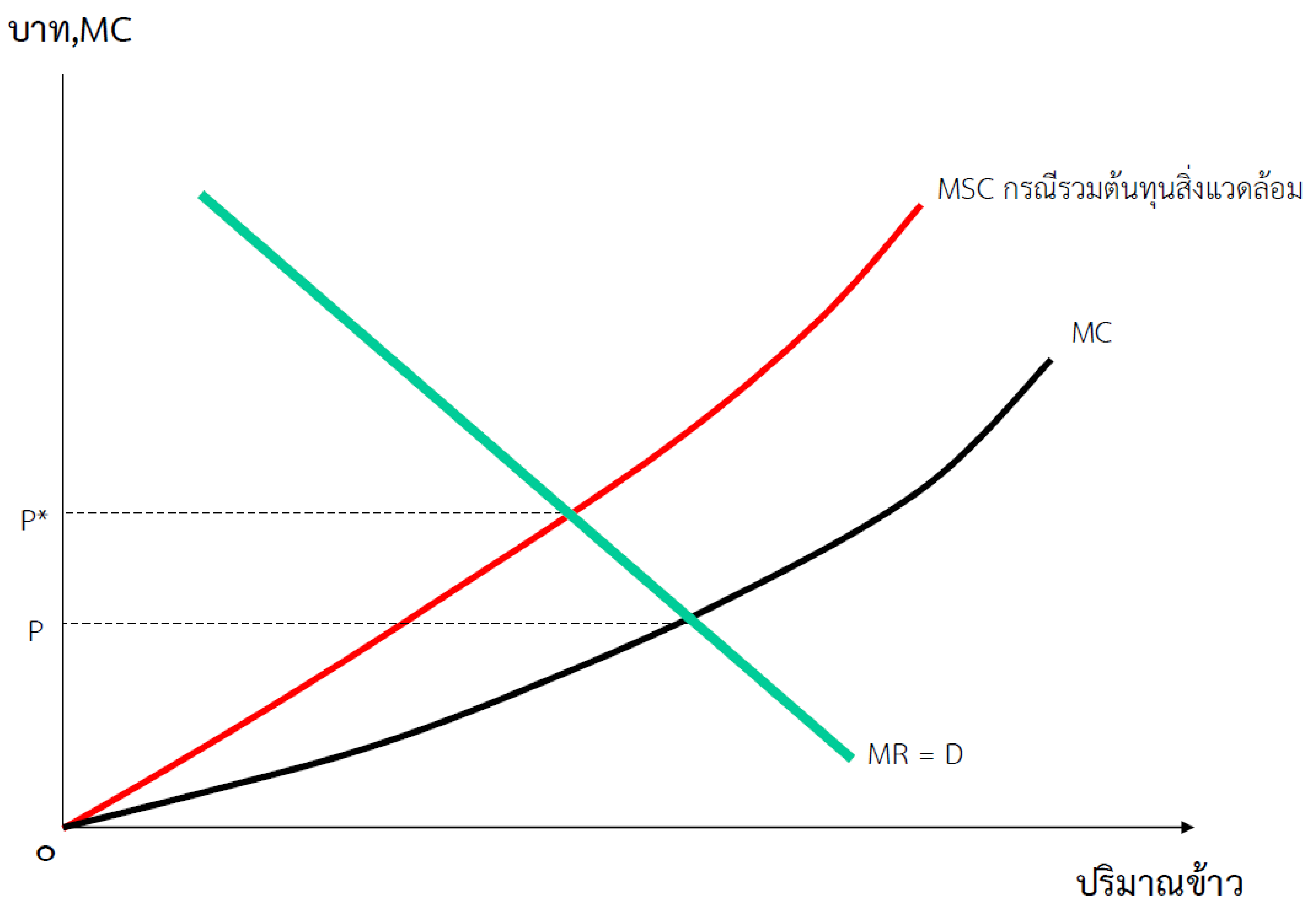
```
. anova   IPCCtotalKgPaddy farmsystem

                          Number of obs =      279     R-squared     =  0.0771
                          Root MSE      = 1.12471     Adj R-squared =  0.0705

              Source |  Partial SS    df       MS           F     Prob > F
          -----------+----------------------------------------------------
               Model |    29.18424     2    14.59212      11.54     0.0000
                     |
          farmsystem |    29.18424     2    14.59212      11.54     0.0000
                     |
            Residual |  349.129818   276  1.26496311
          -----------+----------------------------------------------------
               Total |  378.314058   278  1.36084193
```

6. การคำนวนต้นทุนการทำลายชั้นบรรยากาศ (Climate Damage Costs)

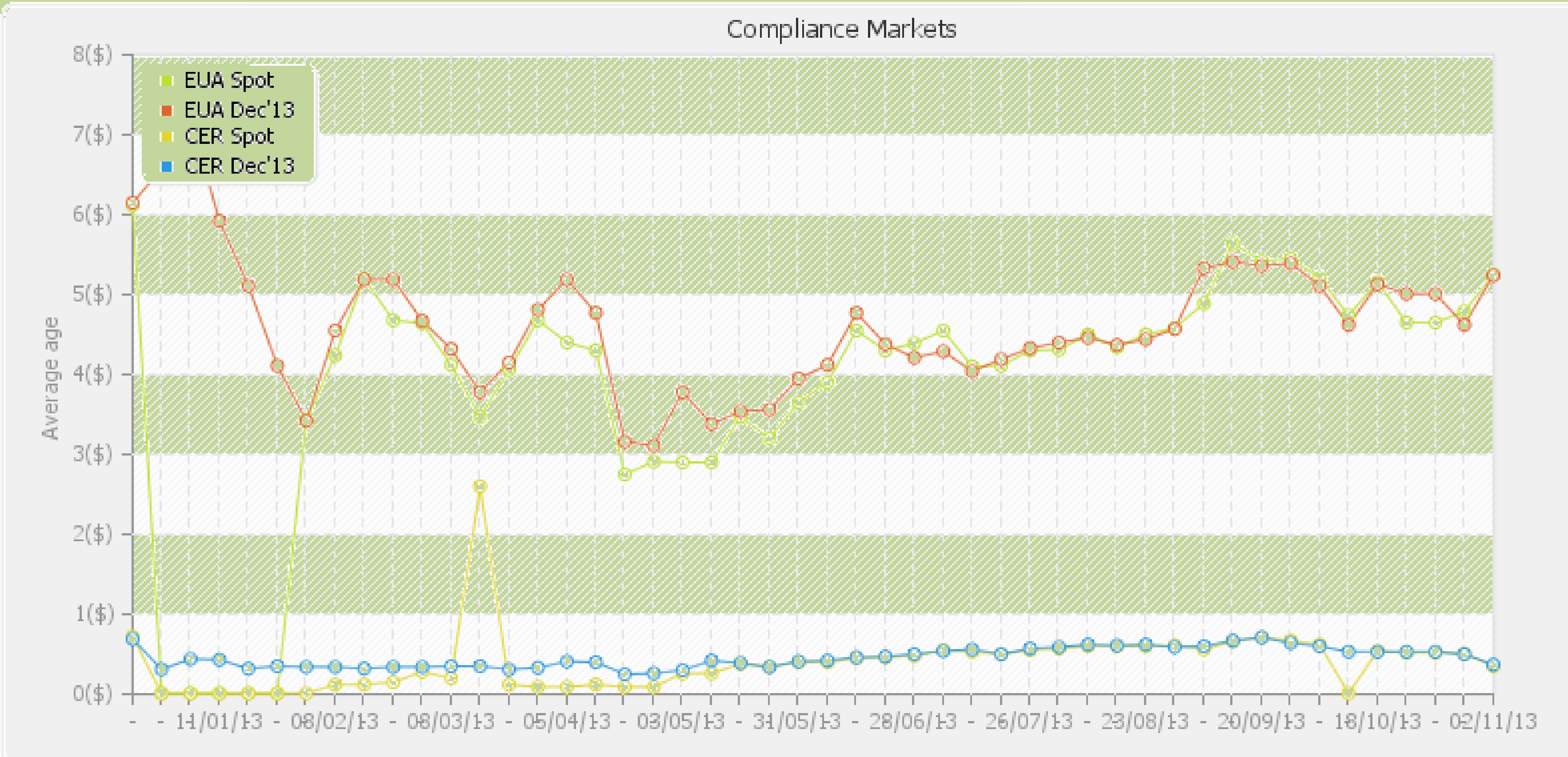




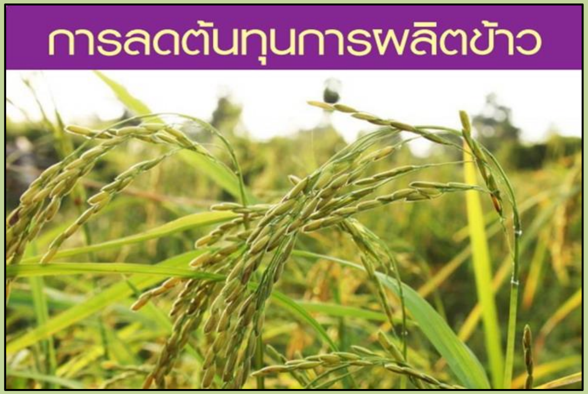



บาท,MC
MSC กรณีรวมต้นทุนสิ่งแวดล้อม
MC
P*
P
MR = D
O
ปริมาณข้าว

Carbon Market Prices



7. สรุปผลและข้อเสนอแนะทางนโยบาย



7.1 สรุปผลการศึกษา

<u>ผลการศึกษา</u>:

- การเลือกใช้สูตรการคำนวณตาม IPCC Guideline 2006 จะให้ค่าการปล่อยก๊าซเรือนกระจกน้อยกว่าการคำนวณตาม Revised IPCC Guideline 1996
- ปริมาณก๊าซเรือนกระจกจากข้าวเปลือกตาม IPCC 2006 และ 1996 มีค่าเท่ากับ 400.40 และ 629.96 kg CO2-e ต่อไร่ ตามลำดับ และ มีค่าเท่ากับ 1.08 และ 1.70 kg CO2-e ต่อข้าวเปลือก 1 kg
- ข้าวเปลือกที่ผลิตจากระบบแบบเกษตรอินทรีย์ ปล่อยก๊าซเรือนกระจกมากที่สุด รองลงมาเป็น ระบบเกษตรดีที่เหมาะสม และระบบเกษตรดั้งเดิม
- ปริมาณก๊าซเรือนกระจกจากการผลิตข้าวเปลือกเป็น 632.45, 503.19 และ 315.11 kg CO2-e ต่อไร่ ตามลำดับ และ มีค่าเท่ากับ 2.00, 1.31 และ 0.86 kg CO2-e ต่อ

7.2 ข้อเสนอแนะทางนโยบาย

- การประเมินการปล่อยก๊าซเรือนกระจก: การวางแผนจัดเก็บข้อมูลกิจกรรมที่ปล่อยก๊าซเรือนกระจกจากนาข้าวที่เป็นระบบและเอื้ออำนวยให้สามารถนำไปใช้ในการคำนวณปริมาณก๊าซเรือนกระจกได้ เพื่อสามารถเลือกใช้วิธีการคำนวน/ประเมินการปล่อยก๊าซเรือนกระจกที่เป็นประโยชน์ที่สุดแก่ประเทศ
- การเจรจาในเวทีระหว่างประเทศ: การวางแนวทางการเจรจาที่เกี่ยวกับการจัดทำบัญชีก๊าซเรือนกระจกของประเทศไทยที่ให้ผลประโยชน์สูงสุดแก่ประเทศได้
- การจัดการฟาร์ม: แม้ว่าเกษตรอินทรีย์และเกษตรดีเหมาะสมจะมีต้นทุนการทำลายชั้นบรรยากาศที่สูงกว่า แต่ ควรมีการประเมินผลได้อื่นๆประกอบด้วย เช่น ความปลอดภัยทางอาหาร และสุขภาพของเกษตรกร

ขอขอบคุณครับ:

ผู้วิจัยหลัก

นางจีราภา โรณีม	เศรษฐกรชำนาญการ
นายอัครพล ฮวบเจริญ	เศรษฐกรปฏิบัติการ
นางสาวปุณณภา พิสกุล	เศรษฐกรปฏิบัติการ
นางสาวจุฑารัตน์ พรหมทัต	เศรษฐกรปฏิบัติการ
นายณภัทร อุ๋ยเจริญ	เศรษฐกรปฏิบัติการ
ว่าที่ ร.ต.ชนธัญ อนิวรรตน์	นักวิเคราะห์นโยบายและแผน
นายอดิเรก เข็มเพ็ชร	นักวิเคราะห์นโยบายและแผน