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Estimates of Greenhouse Gas Emissions associated with Agriculture (Food Production) in SSEA

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Acknowledgements

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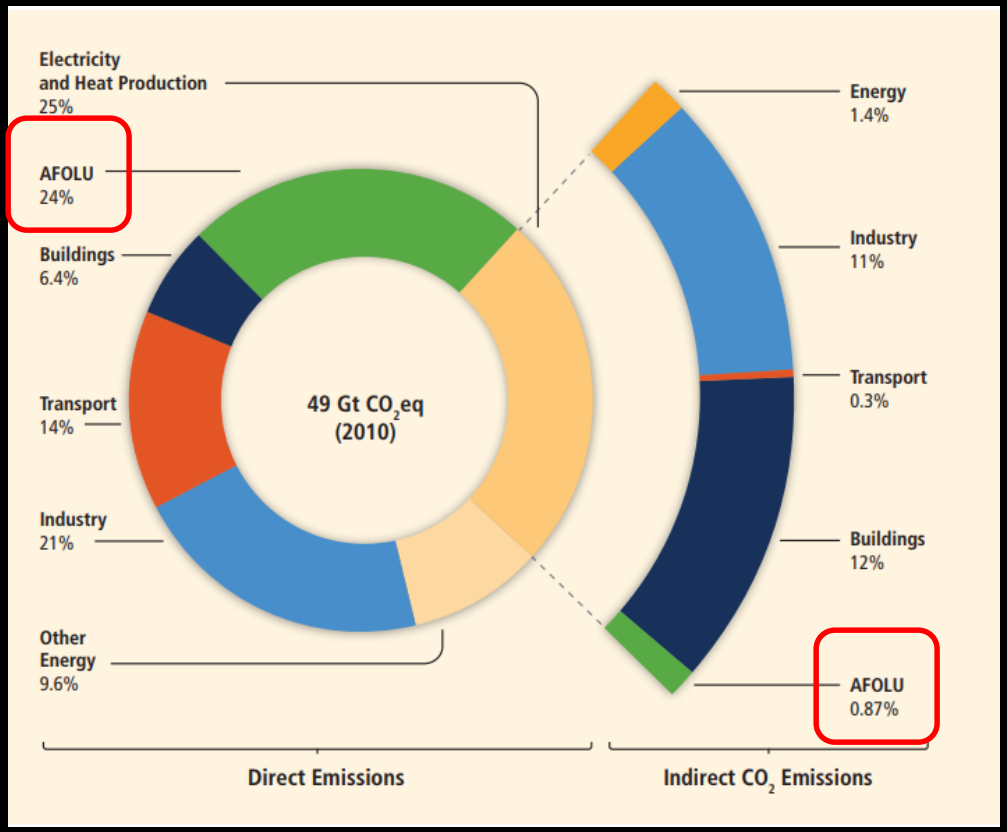
How Much is the Current Contribution of AFOLU to GHG Emissions?



- Annual GHG emissions from agricultural production in 2000-2010 were estimated at 5.0-5.8 $GtCO_2eq/yr$ (10-12%)
- Annual GHG flux from land use and land-use change activities accounted for approximately 4.3-5.5 $GtCO_2eq/yr$ (9-11%)

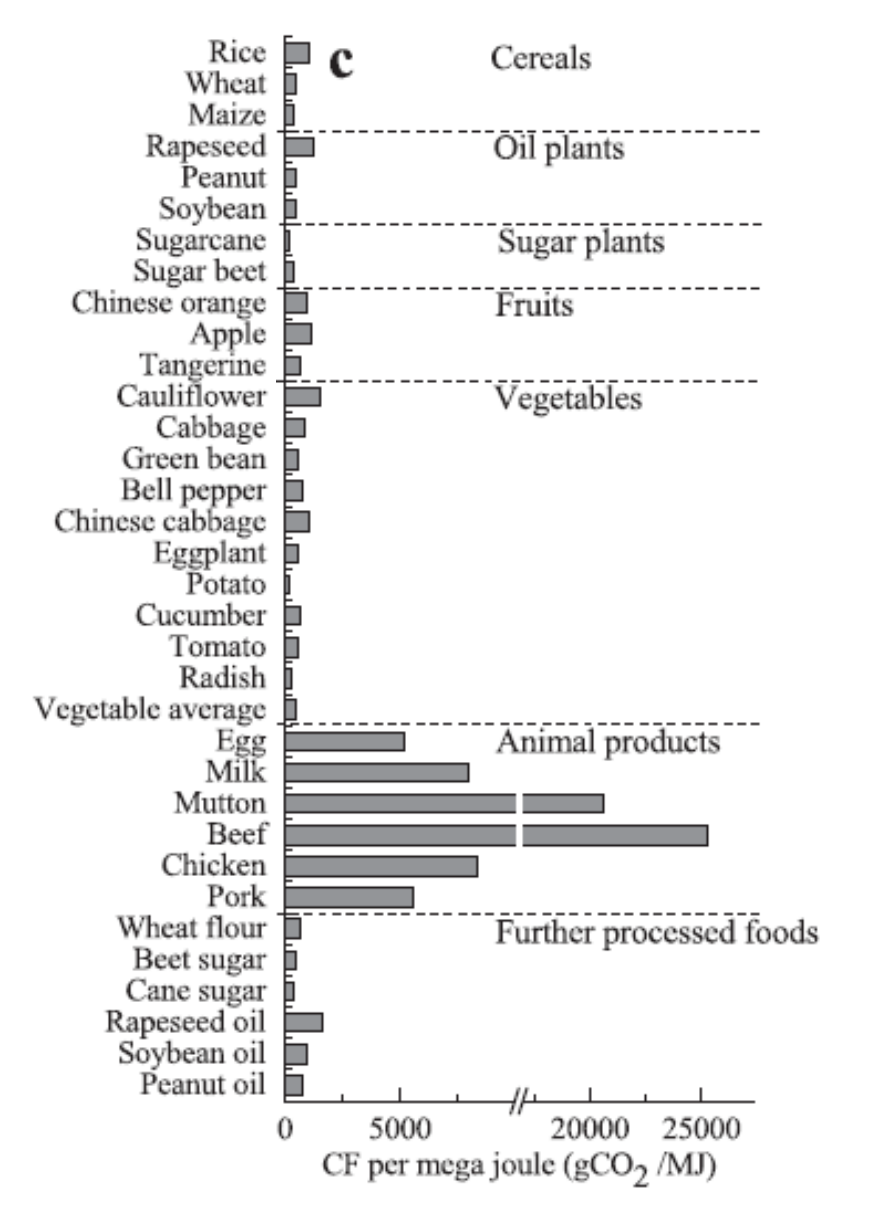
AFOLU: Agriculture, Forestry and Other Land Use

IPCC AR5 WG3 report, 2014

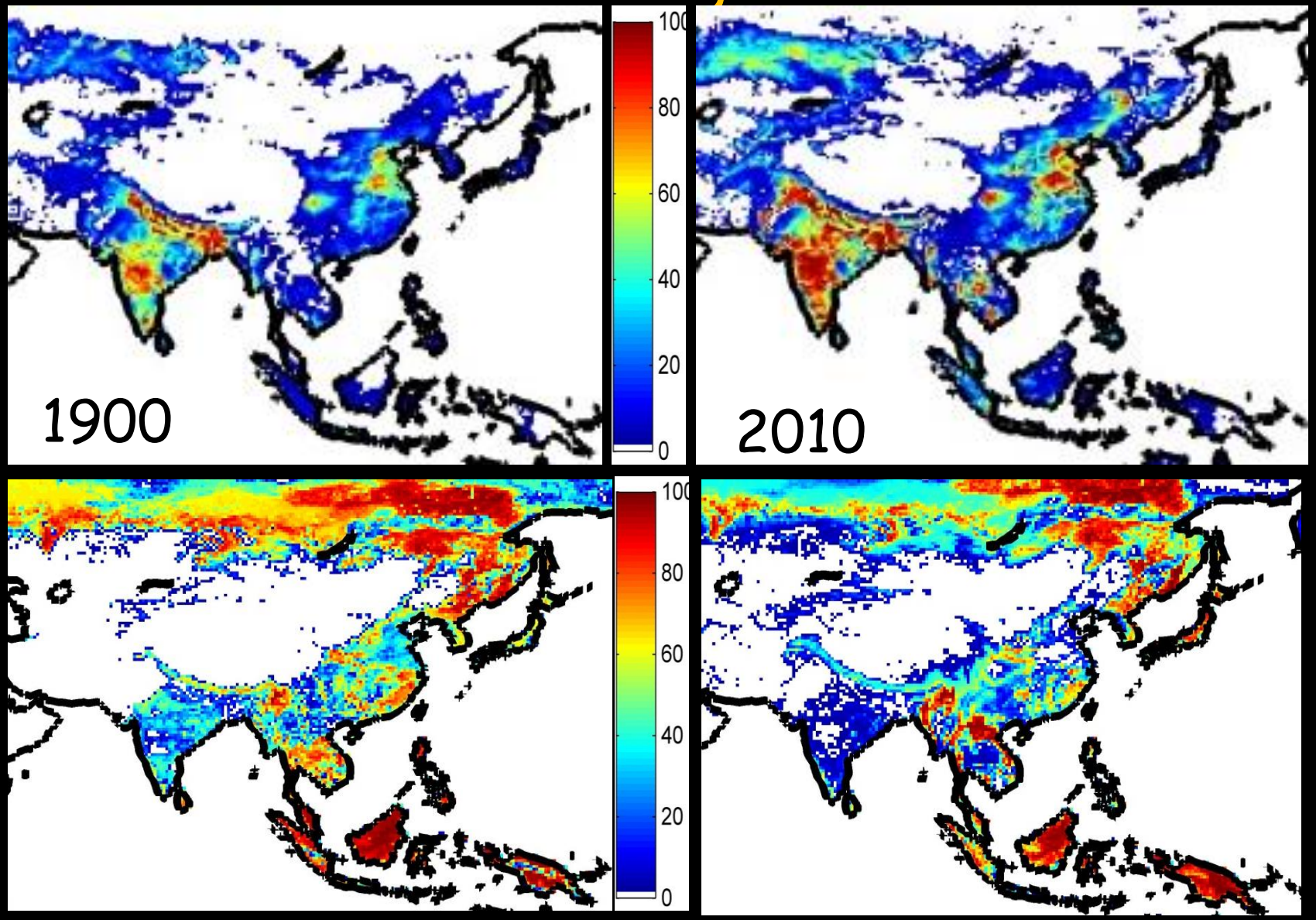
Overall Objective

- Estimates of GHG emissions from Agricultural, Forestry and Other Land Use (AFLOU) Changes in South and South East Asia (SSEA)

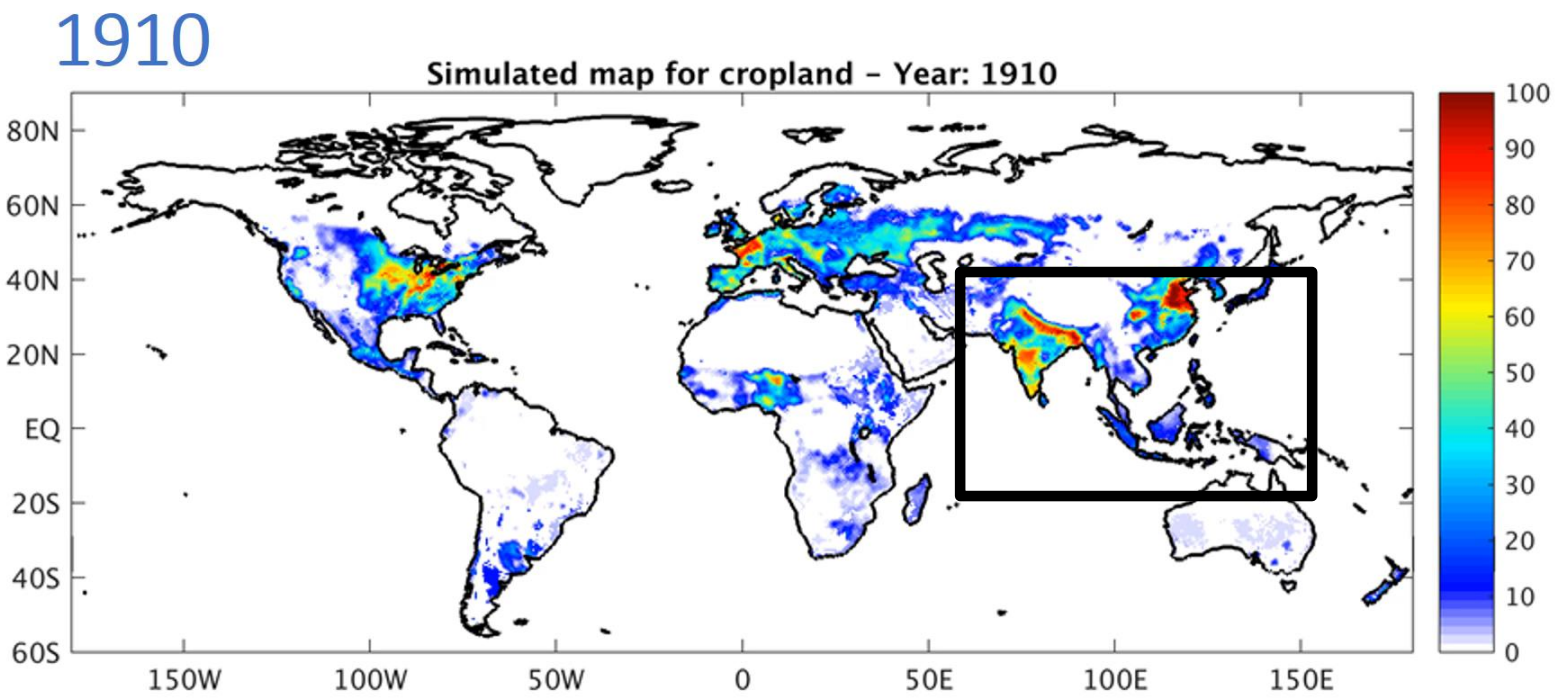
Carbon Footprint – Agriculture Sector (GHG Emissions from the Entire Cycle)



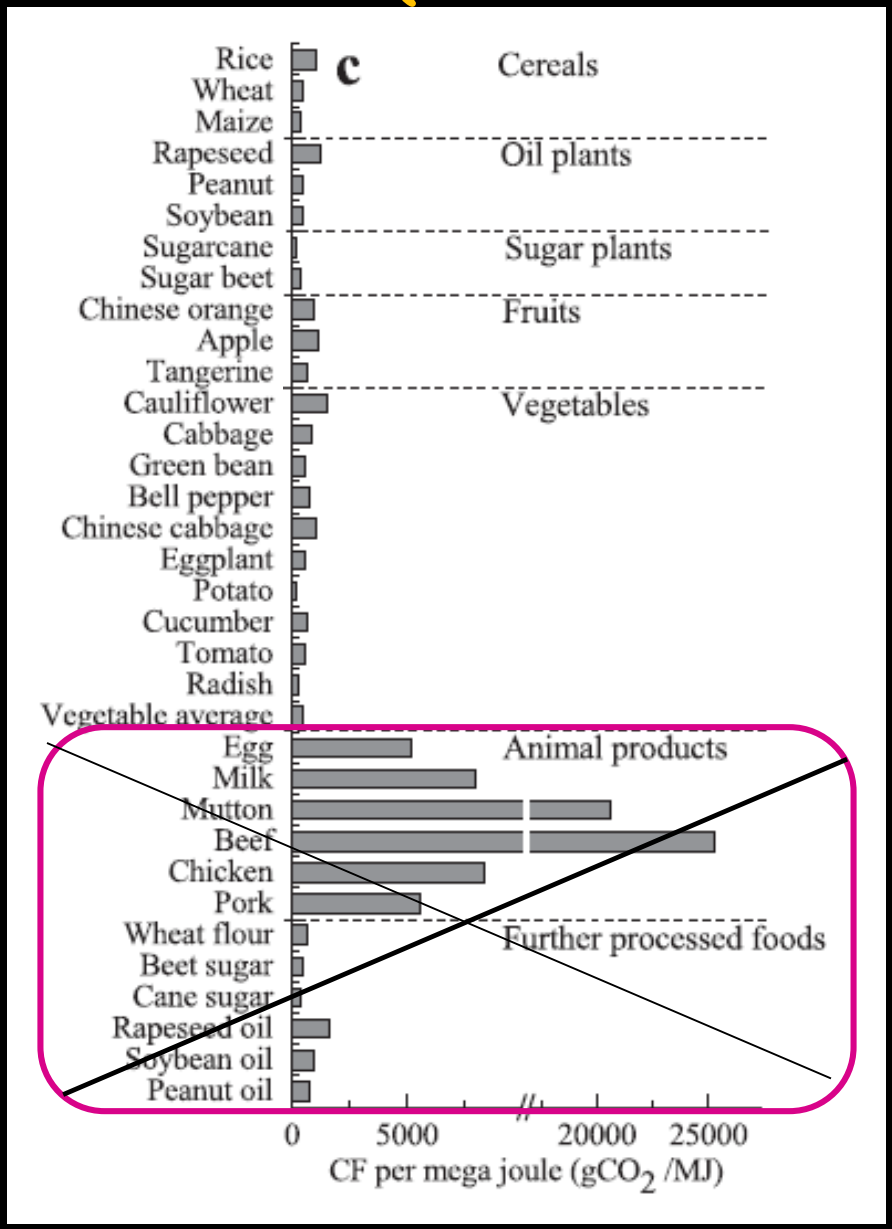
Land Use Changes Due to Human Activities
Unit: % of grid cell



LCLUC – Changes for Cropland over the Past Century and Projection for the Future (SSP4-RCP6.0)



Carbon Footprint – Agriculture Sector (GHG from the Entire Cycle)



Question:

What are the spatial patterns of the life cycle Carbon Footprints of major plant-based ~~and animal-based~~ foods?

Note: 1 Mega Joule = 239 kilocalorie

(Xu et al. (2019)

What are the spatial distributions of Major Crops in SSEA

Five Major Crops:

- Rice
- Wheat
- Maize
- Cotton
- Oil palm

Leff et al, GBC, 2004

We Studied All Crops Grown in SSEA (96 crops)

- Sugarcane
- Rice
- Oilpalm
- Wheat
- Cassava
- Maize
- Vegetablenes
- Potato
- Coconut
- Banana
- Cotton
- Mango
- Onion
- Fruitnes
- Soybean
- Tomato
- Millet
- Tropicalnes
- Groundnut
- Eggplant
- Orange
- Cabbage
- Bean
- Rubber
- Chickpea
- Pineapple
- Sorghum
- Cauliflower
- Rapeseed
- Pumpkinetc
- Sweetpotato
- Papaya
- Okra
- Pigeonpea
- Greenpea
- Lemonlime
- Jute
- Watermelon
- Apple
- Coffee
- Greenbean
- Tea
- Sesame
- Sunflower
- Plantain
- Barley
- Melonetc
- Carrot
- Garlic
- Castor
- Tobacco
- Rootnes
- Lentil
- Pulsenes
- Cucumberetc
- Lettuce
- Tangetc
- Grapefruitetc
- Grape
- Cocoa
- Citrusnes
- Pea
- Greencorn
- Date
- Pear
- Spinach
- Peachetc
- Pepper
- Oilseednes
- Plum
- Avocado
- Mustard
- Cowpea
- Cerealnes
- Apricot
- Taro
- Safflower
- Linseed
- Berrynes
- Jutelikefiber
- Nutnes
- Asparagus
- Walnut
- Sugarbeet
- Canaryseed
- Almond
- Yam
- Fig
- Stonefruitnes
- Buckwheat
- Cherry
- Broadbean
- Greenbroadbean
- Pistachio
- Hempseed
- Sisal

Data source: FAOSTAT dataset

Estimating GHG Emissions: Method

- Life cycle assessment: GHG emission (CO_2, CH_4, N_2O)

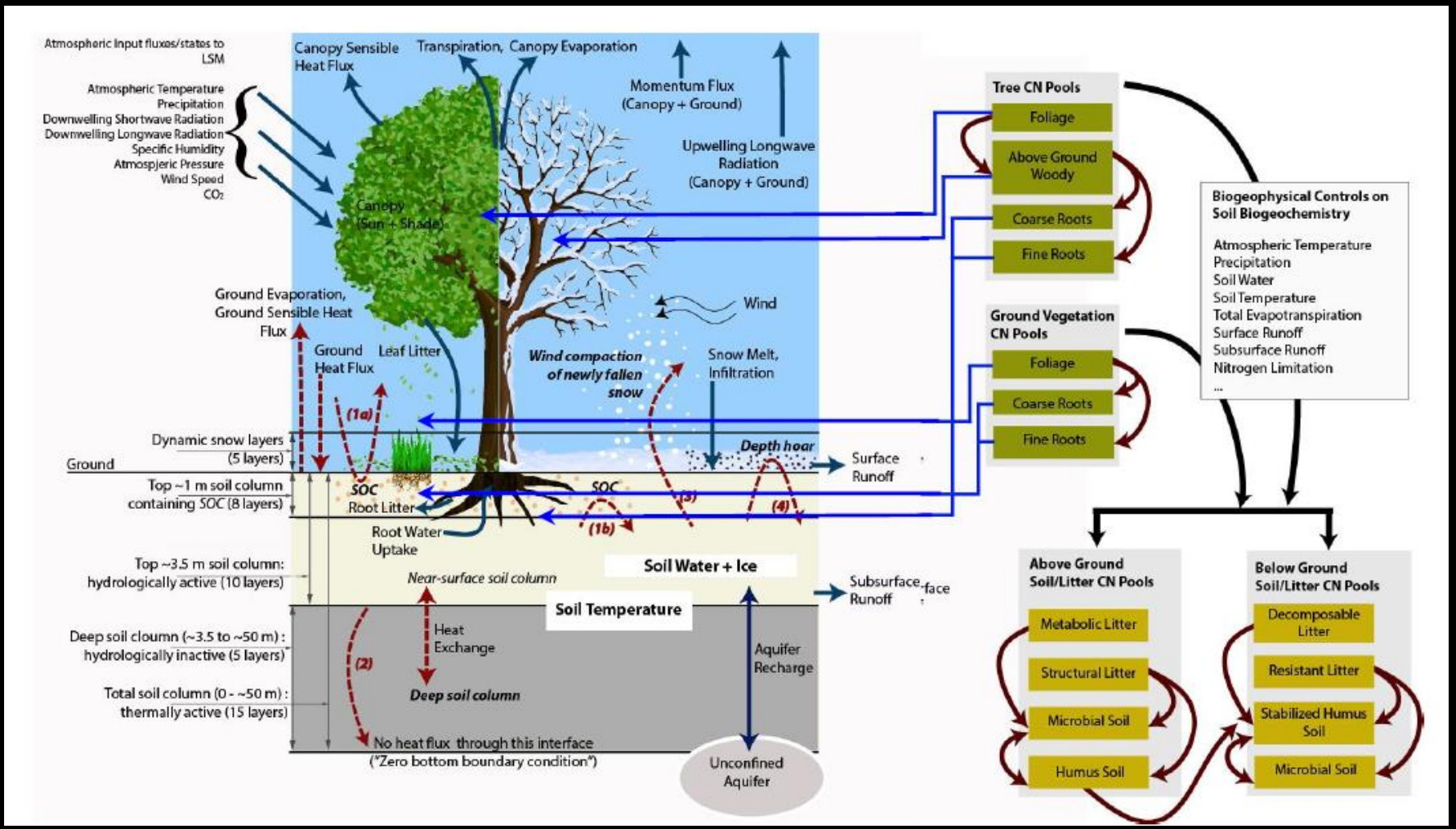
Manufacturing (including mining and transportation):
fertilizers, pesticides, energy, fuels, etc.

Machinery

Farming (field emissions):
change in SOC, CH_4, N_2O

- Use Global Warming Potential to estimate GHG emissions in CO_2

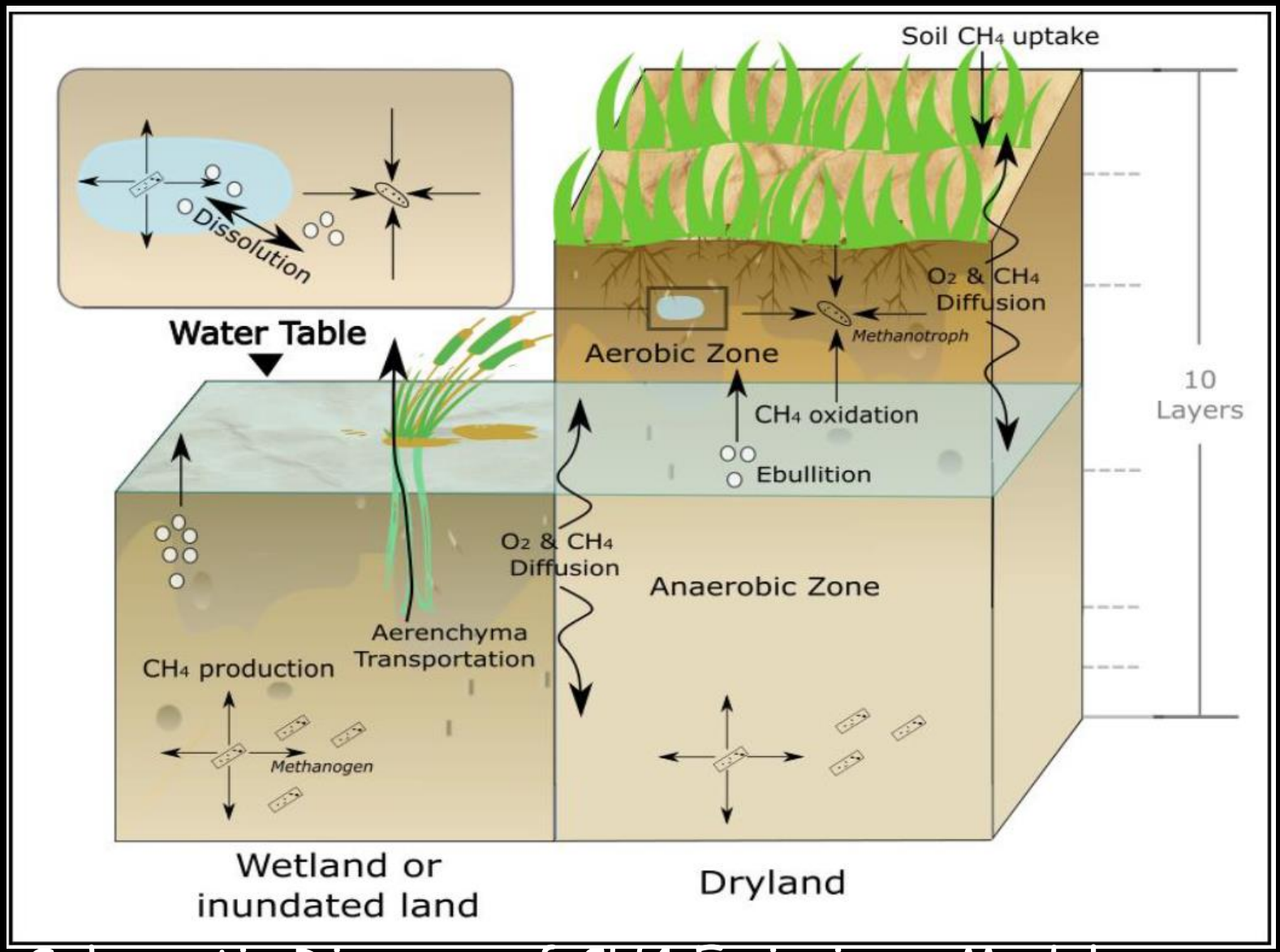
Field and LULCC emissions for CO_2 and N_2O using ISAM



Schematic Diagram of Biogeochemistry and Biogeophysical process to estimate CO2, and N2O from farm and LULCC in ISAM Module

(Barman et al. (2014)

Field Emissions for CH_4 using ISAM

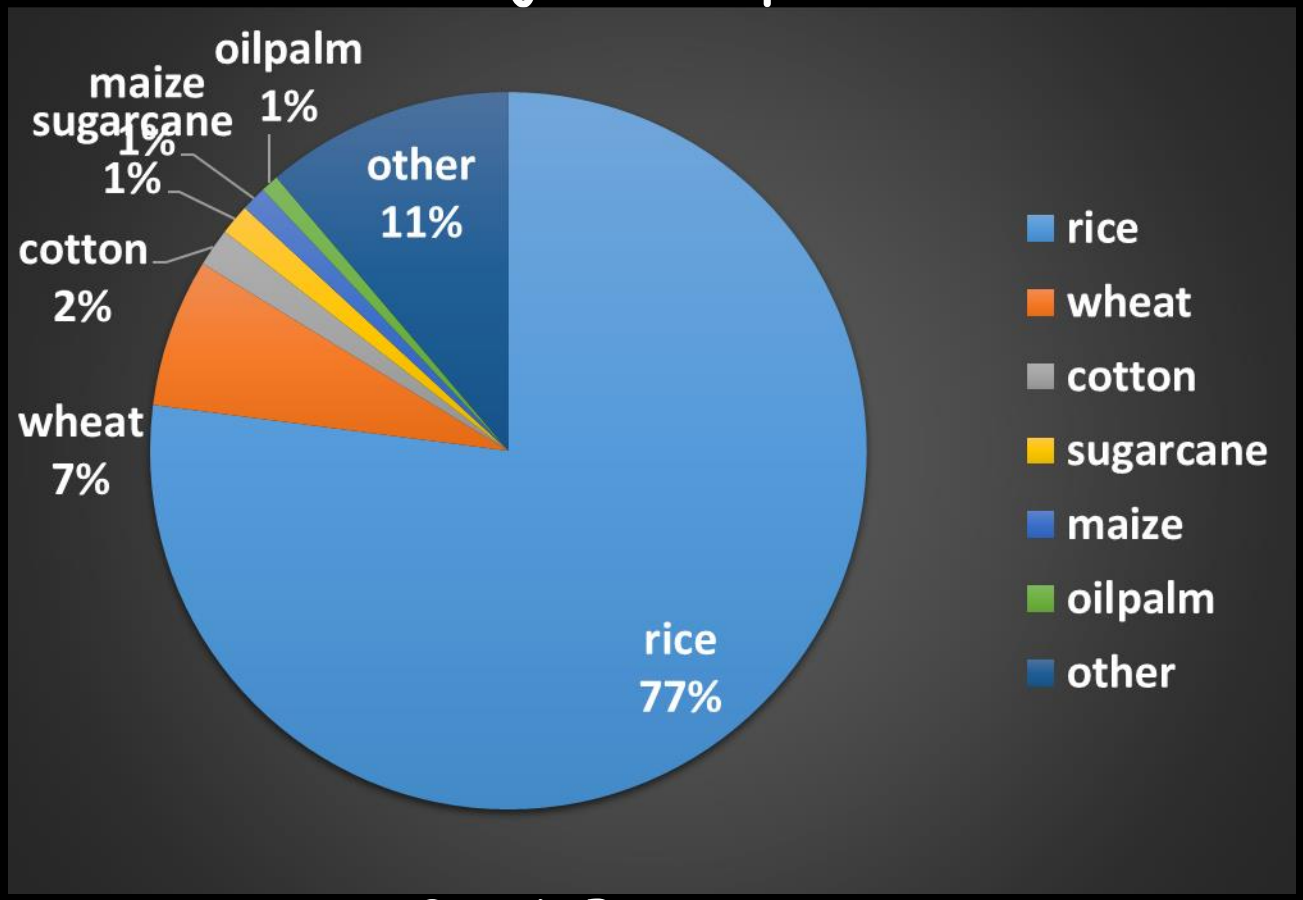


Schematic Diagram of CH4 Emissions Module

(Shu et al., 2019)

GHG Emissions from Crop Production for SSEA (2000s)

Major Crops

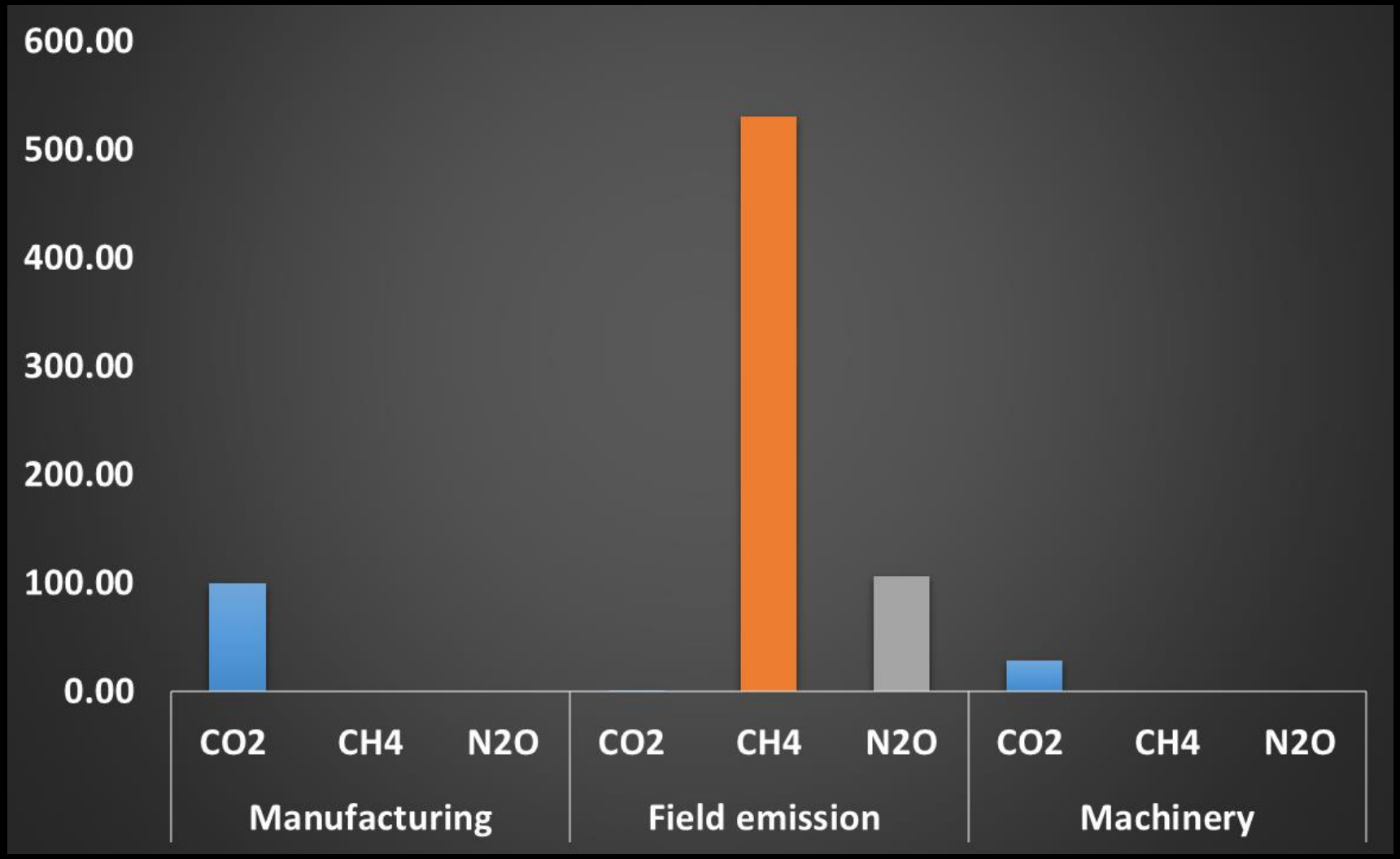


0.76 Pg CO_2-eq.

(43.2% of global total: 1.76 Pg CO_2-eq.)

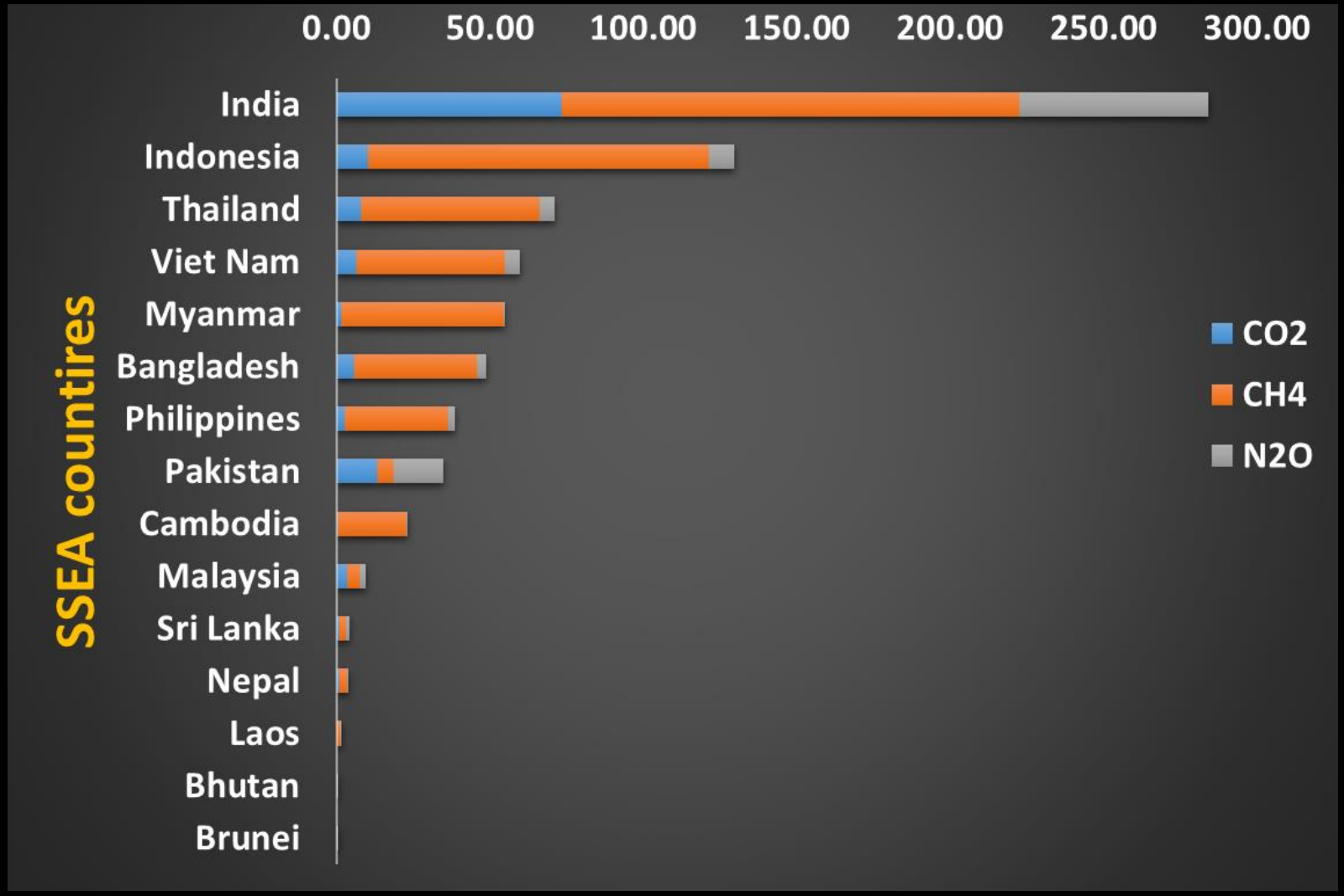
(Xu et al., 2019)

Manufacturing, Field and Machinery Emissions for SSEA (Unit: Tg CO_2 eq.)



(Xu et al., 2019)

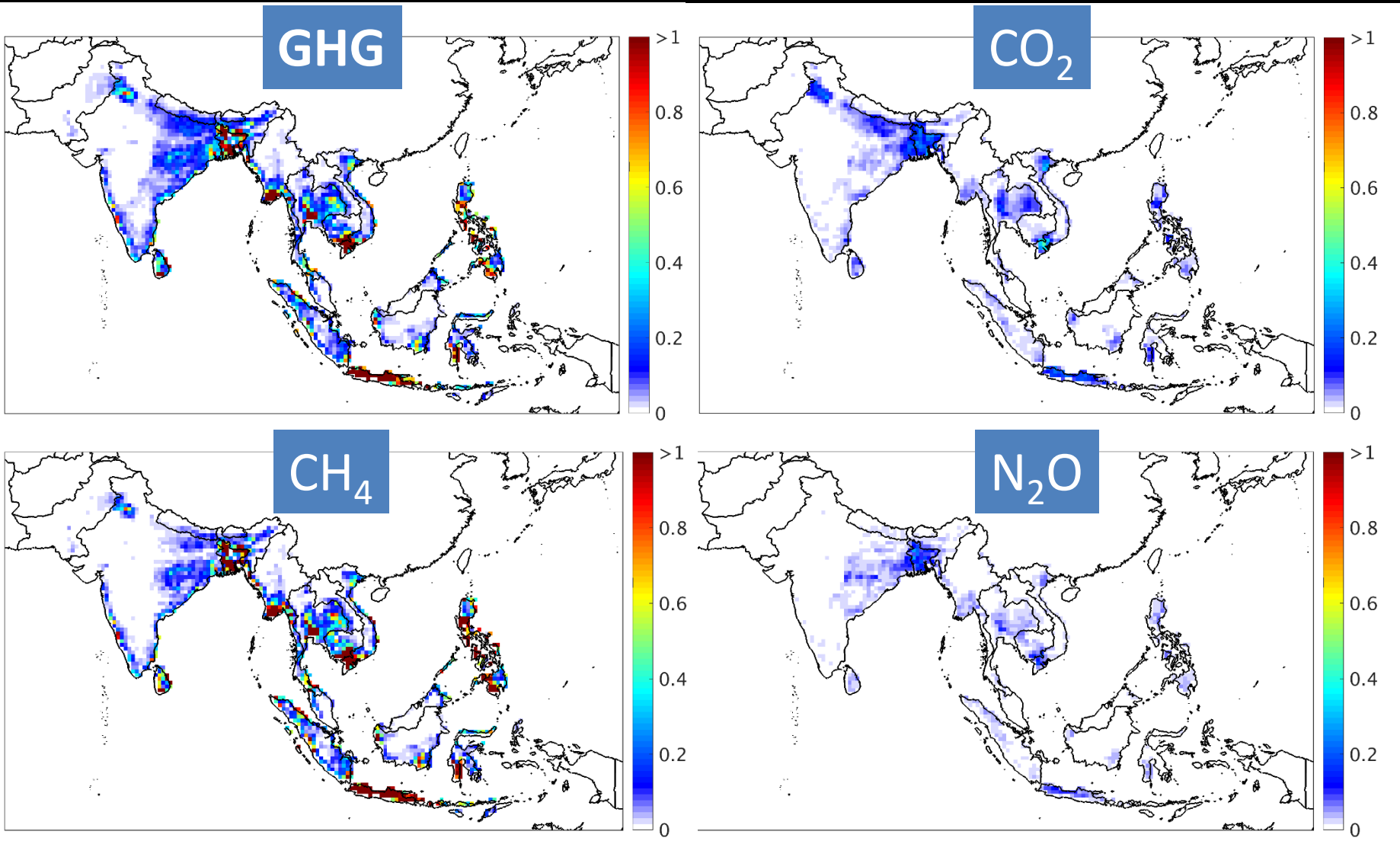
GHG Emissions by Country (Unit: Tg CO_2 Equivalent)



(Xu et al., 2019)

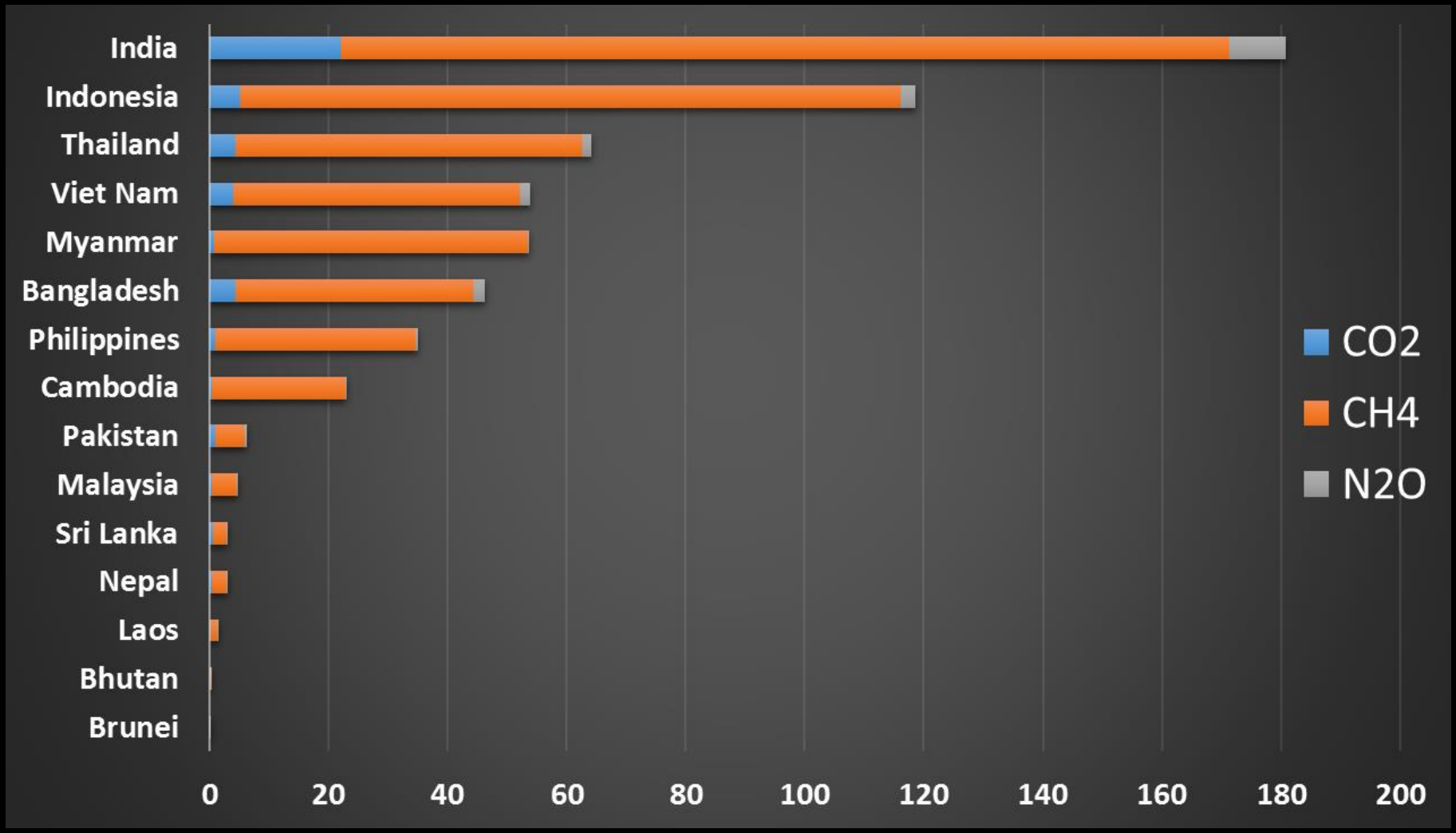
Crop Specific Emissions: Rice

GHG emissions of Rice (unit: Tg CO_2 eq.)



(Xu et al., 2019)

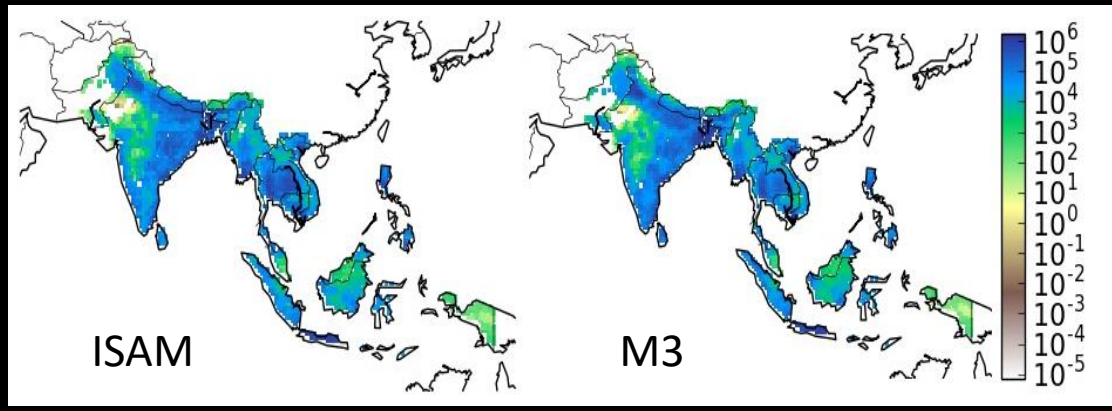
Rice Emissions by Country (unit: Tg CO_2 eq.)



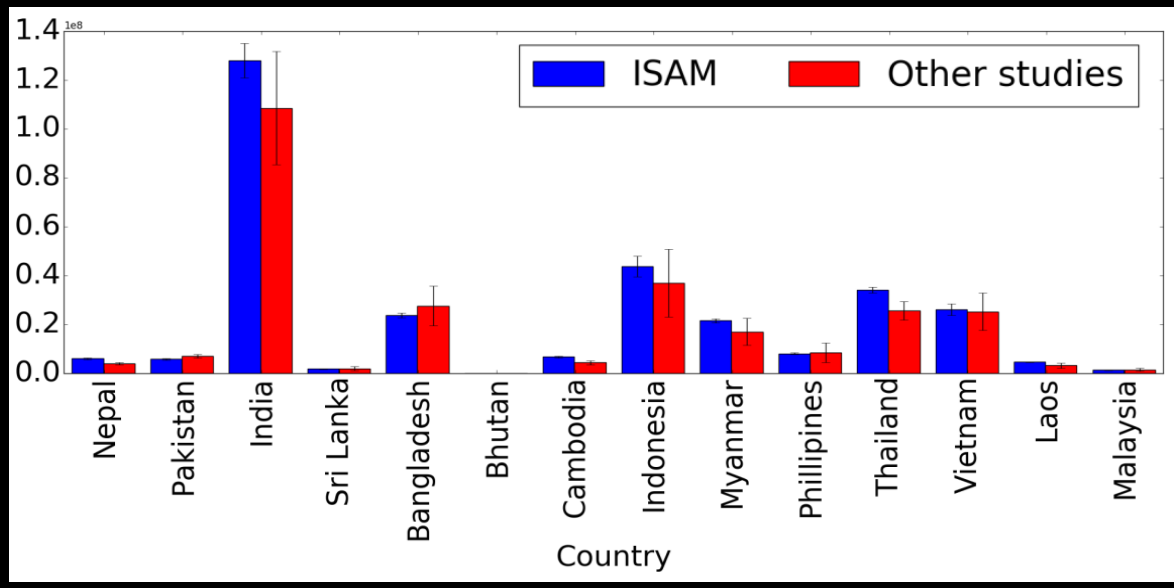
(Xu et al., 2019)

Model Evaluation for Rice Production

ISAM Estimated Production (tons/0.1° gridcell) with Monfreda et al. (2008) average for the period 1997-2003



ISAM Estimated Production (tons/yr) at country-level over the period 1997-2005 with other studies



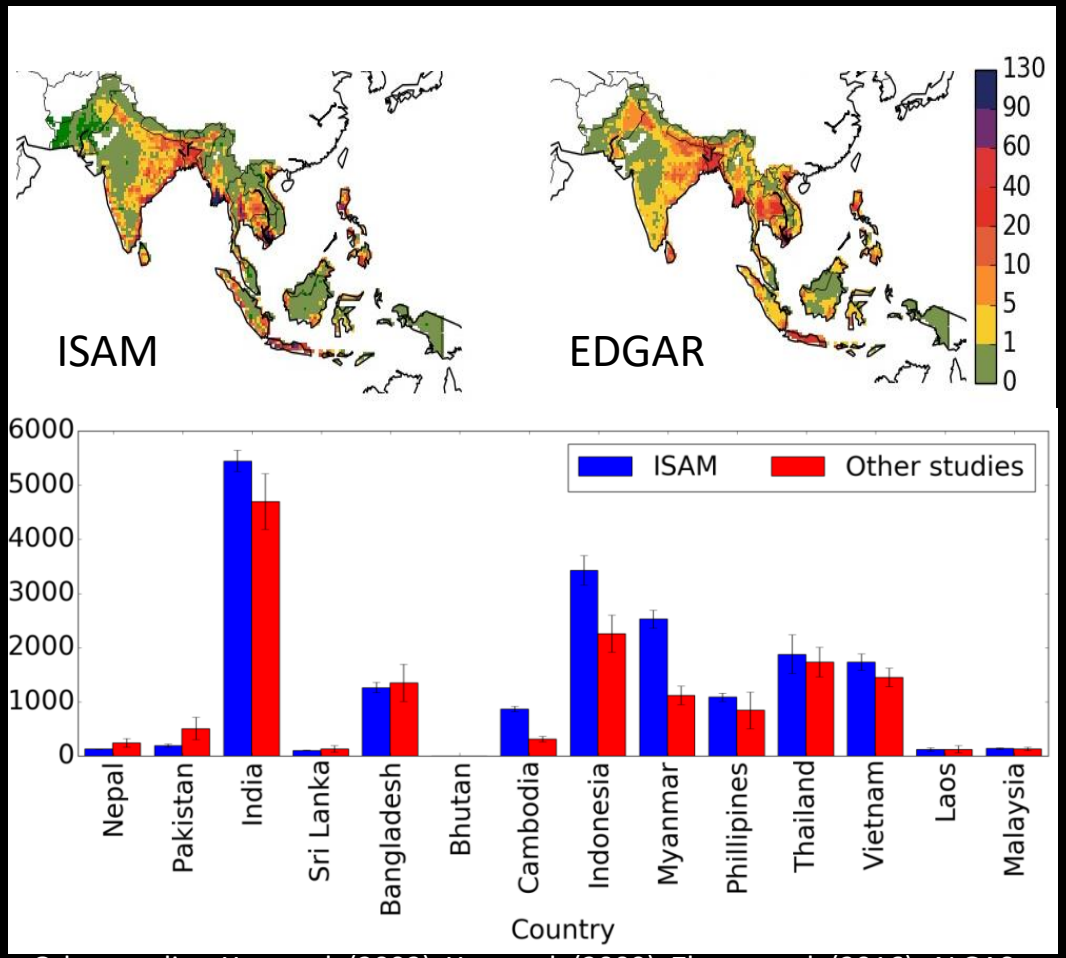
Other studies: Iizumi et al. (2014, 1997-2005), Monfreda et al. (2008, M3-2000), You et al. (2014, SPAM2005), FAO 1997-2005

(Lin et al., 2018)

Model Evaluation for CH_4 Emissions

ISAM Estimated methane emissions (Gg CH_4/0.1° gridcell) for 1995 compared with EDGAR

ISAM Estimated methane emissions (Gg CH_4/yr) at country-level over the period 1995-2000 with other studies

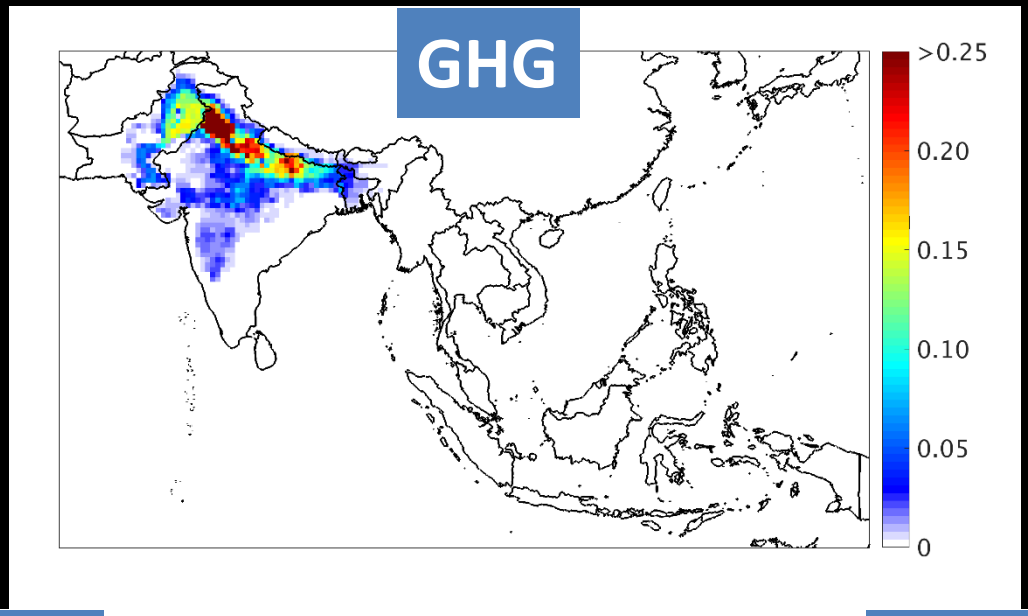


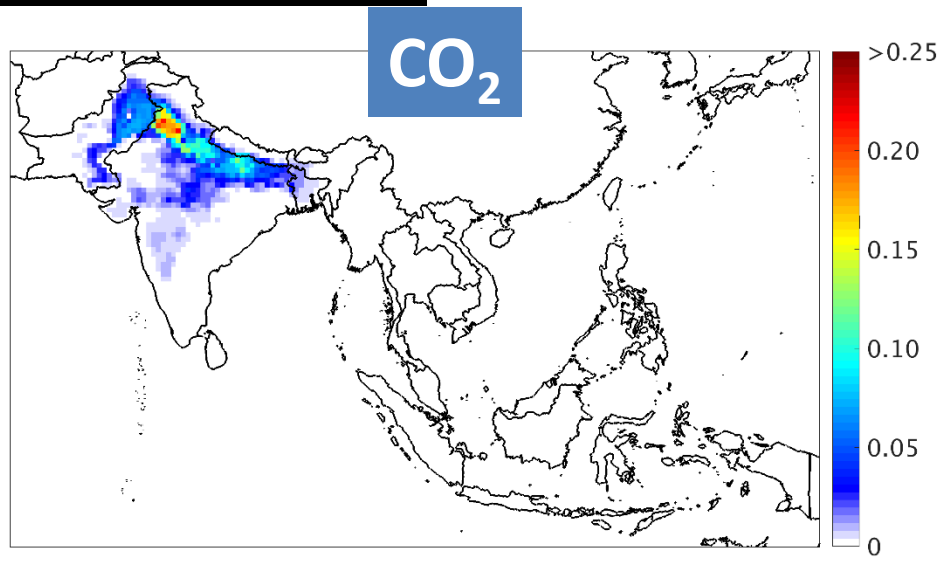
Other studies: Yan et al. (2003), Yan et al. (2009), Zhang et al. (2016), ALGAS (Asia Least Cost Greenhouse Gas Abatement Strategy) report, UNFCCC national communication, FAO 1995-2000, EDGAR (Emission Database for Global Atmospheric Research) 1995-2000

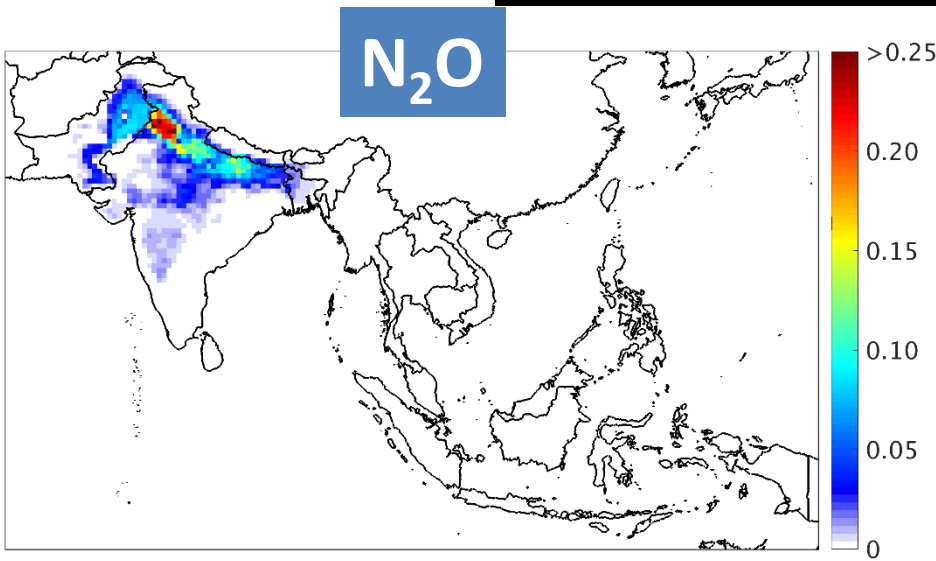
(Lin et al., 2018)

Crop Specific Emissions: Wheat

GHG emissions of Wheat (unit: Tg CO_2 eq.)

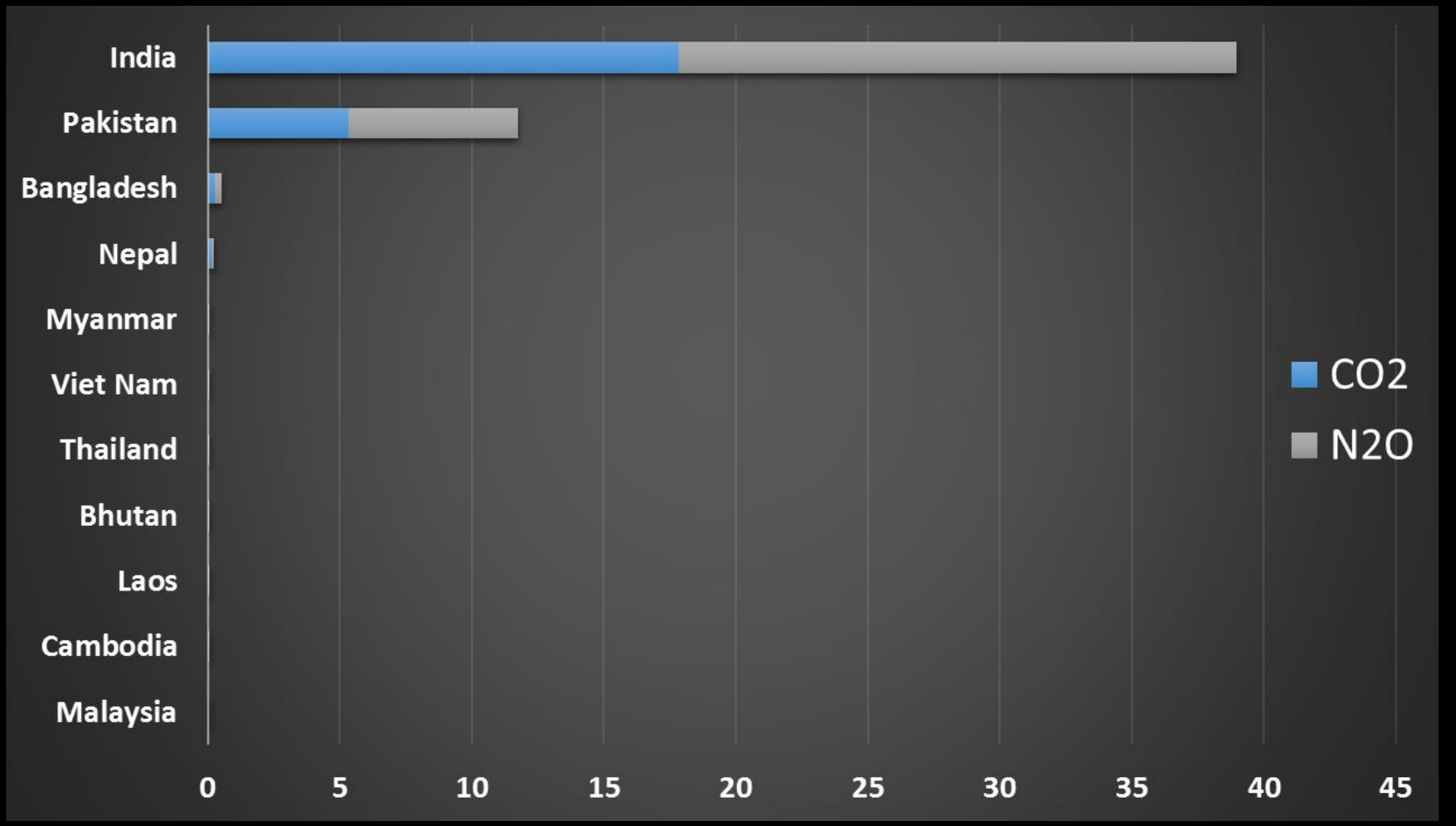






(Xu et al., 2019)

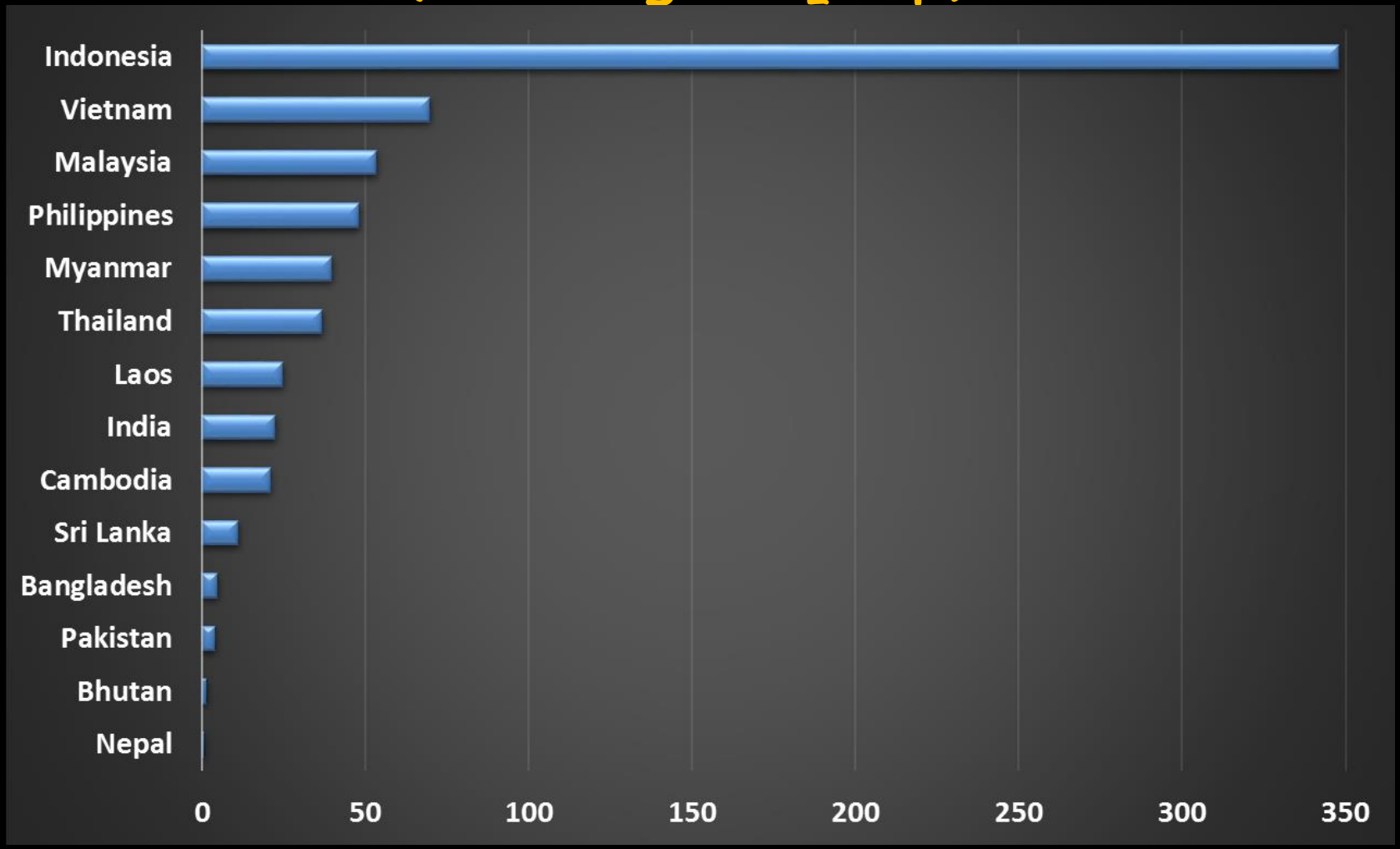
Wheat Emissions by Country (unit: Tg CO_2 eq.)



(Xu et al., 2019)

LCLUC by Country

LCLUC GHG emissions by country (2000s) (unit: Tg CO_2 eq.)



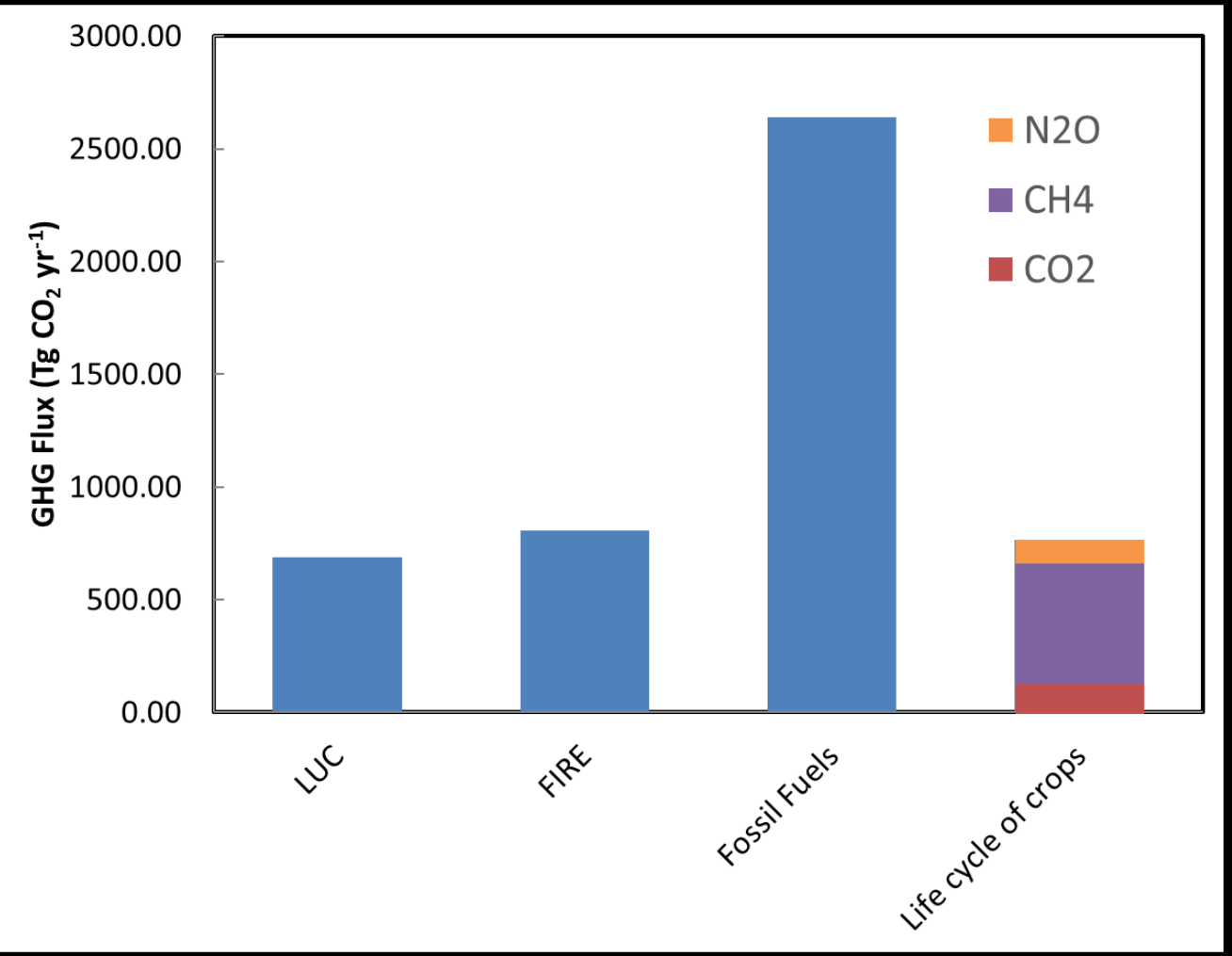
Total emission due to LCLUC: 0.70 Pg CO_2 eq. /yr

(Cerverich et al., 2016)

SSEA Total Emissions by Various Categories

GHG emissions of SSEA (unit: Tg CO_2 eq.)

Total emission: 4.9 Pg CO_2 eq. /yr



LCLUC	0.7 $PgCO_2$/yr (14%)
Fire	0.8 $PgCO_2$/yr (16%)
Fossil	2.6 $PgCO_2$/yr (51%)
LCA	0.8 $PgCO_2$/yr (20%)
Total Emissions	4.9 $PgCO_2$/yr
Net Sink	-2 $PgCO_2$/yr
Net Flux	2.9 Pg CO2

(Xu et al., 2019)

Major Findings

- India and Indonesia are the two highest emitters of GHG emissions in SSEA
- CH_4 is the most important GHG in crop production in SSEA
  - Due to rice cultivation, particularly during plant growth (field emission)
- Wheat cultivation emits both CO2 and N2O
  - CO_2 during fertilizer manufacturing and
  - N_2O due to N fertilizer application

The End