# Contribution of Nitrous Oxide in Life Cycle Greenhouse Gas Emissions of Novel and Conventional Rice Production Technologies

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# Background

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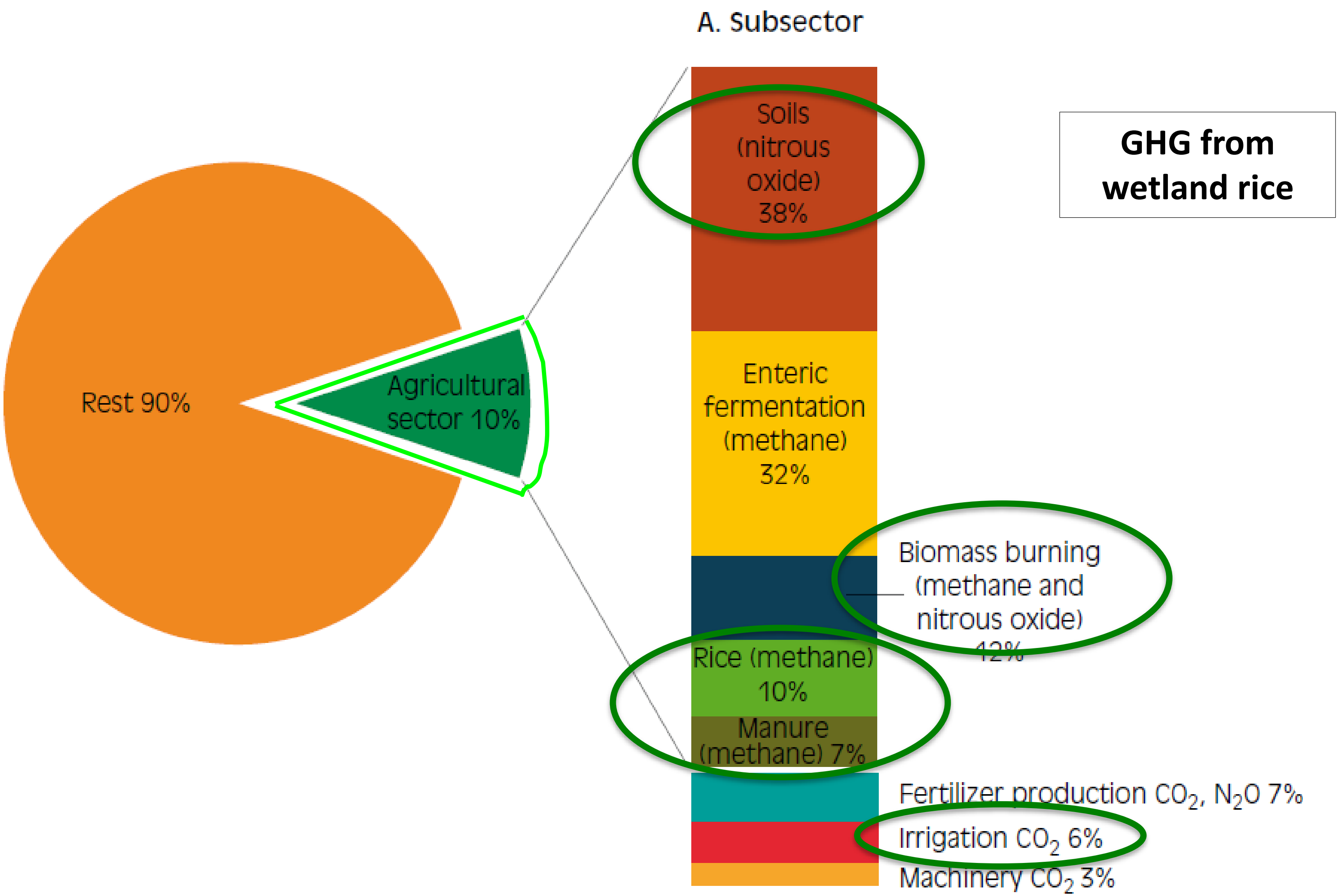
# Wetland rice production and global budget of GHGs




**GHGs from agriculture counting direct agricultural emissions plus input production and energy use**

Adapted from Bellarby et al. 2008

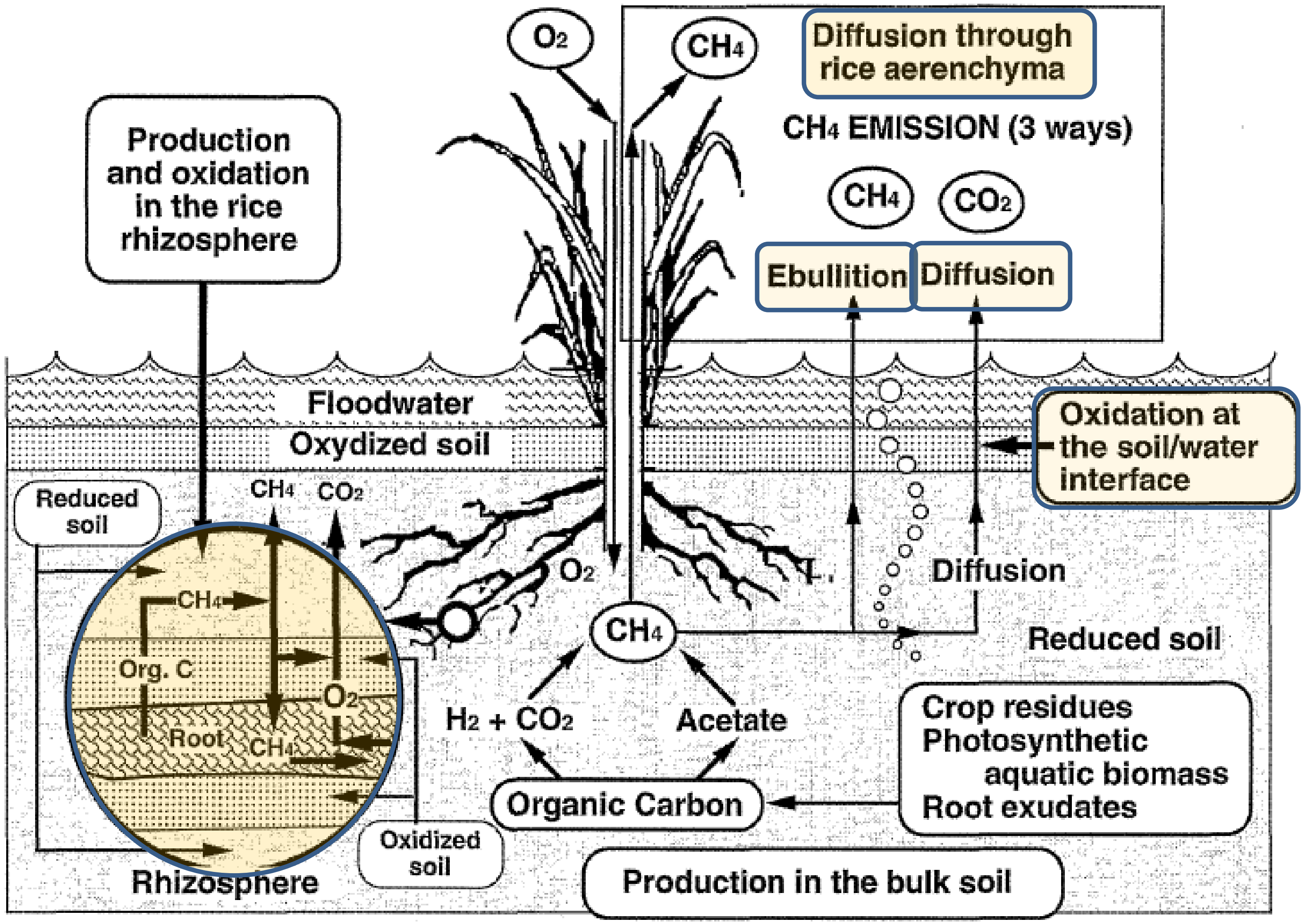



**Fig. Production, consumption and transfer of $CH_4$ to the atmosphere in rice field (Adapted from Le Mer and Roger, 2001)**

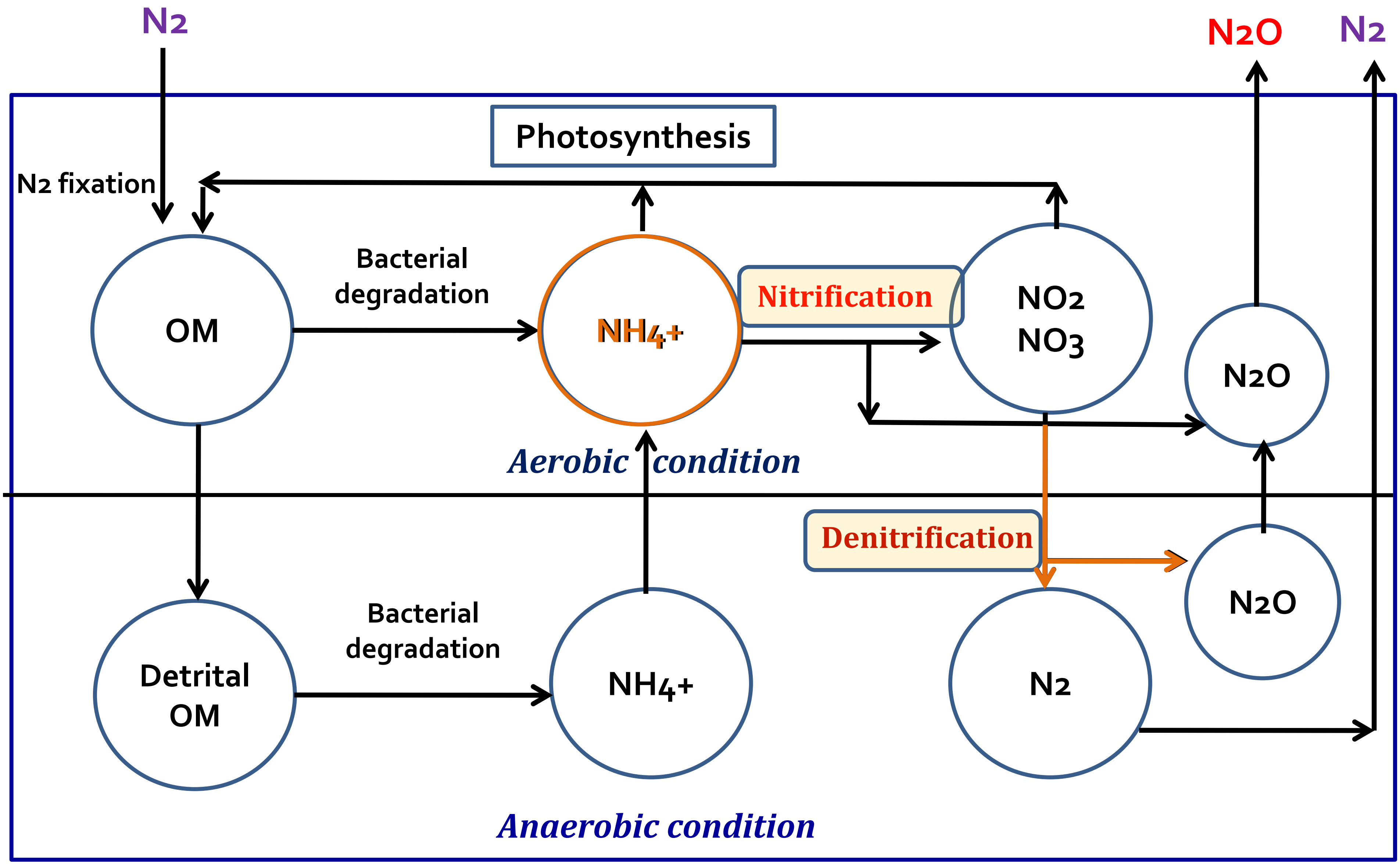
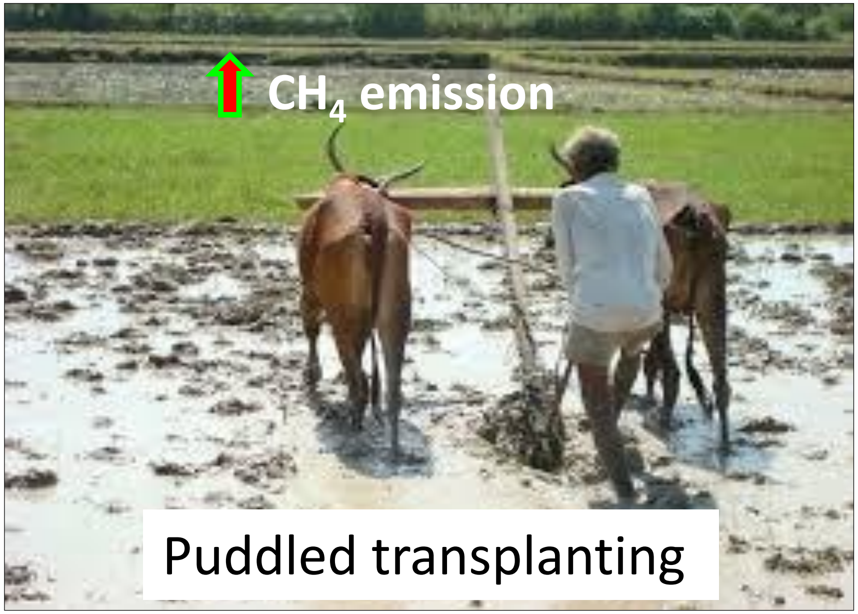


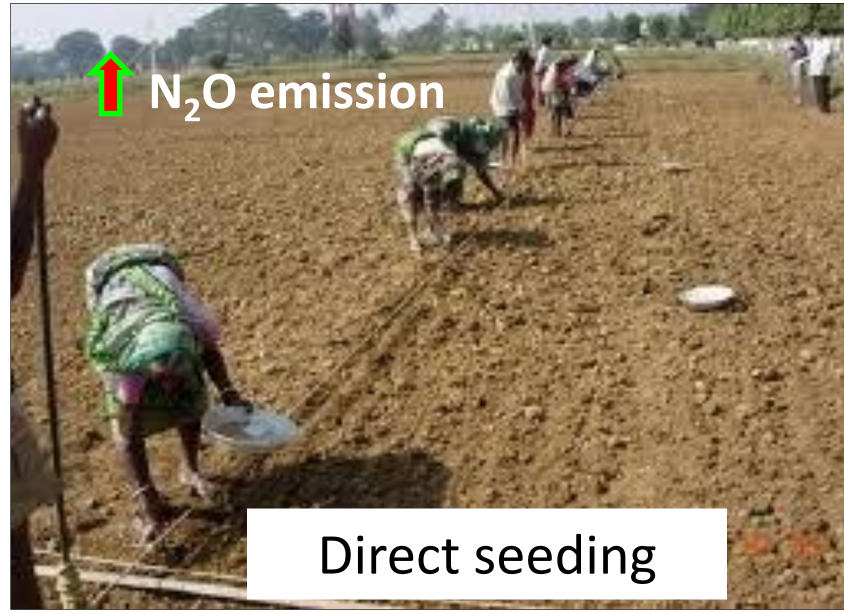

**Fig. $N_2O$ production in soil through microbial transformations**

# Novel technologies to cope with the paucity of labour and water

**Constraints**




Puddled transplanting




Direct seeding


Mechanical transplanting


System of Rice Intensification

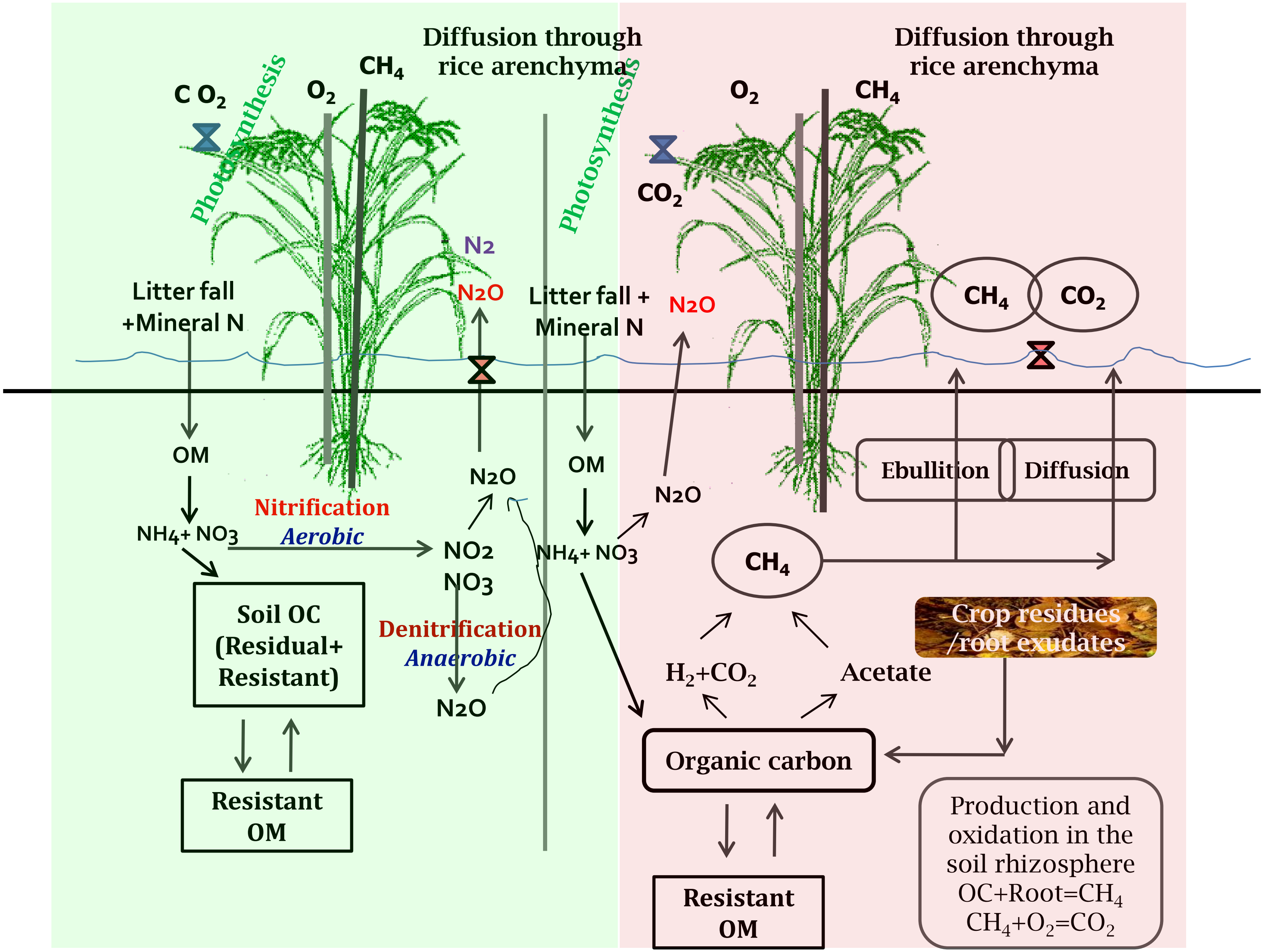



**Fig. Trade off between $CH_4$ and $N_2O$ under wetland rice conditions**

## A novel solution – Non-puddled transplanting of rice

# Development

**Non-puddled transplanting of rice/NP rice**

# Objectives:

- To assess the contributions of $N_2O$ to life cycle GHG emissions for CT and NP with crop residue retention levels
- To determine the hotspots contributing significantly to the GHG emissions within the system boundaries by a LCA study
- To identify the causes for the predominant GHG emissions during the pre– and on–farm stages of rice production.

# Methods

# Methods

- **Study site: Alipur, Rajshahi**

# Closed Chamber method

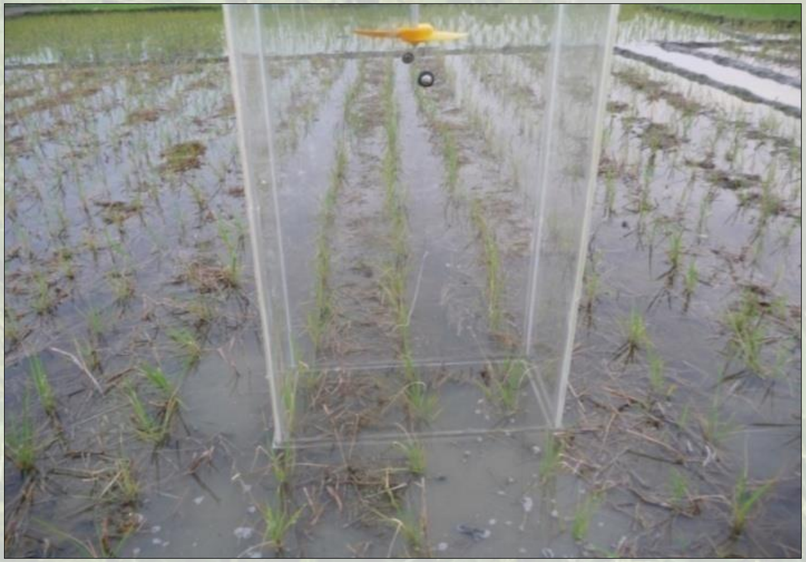
## Closed chamber for microbial respiration

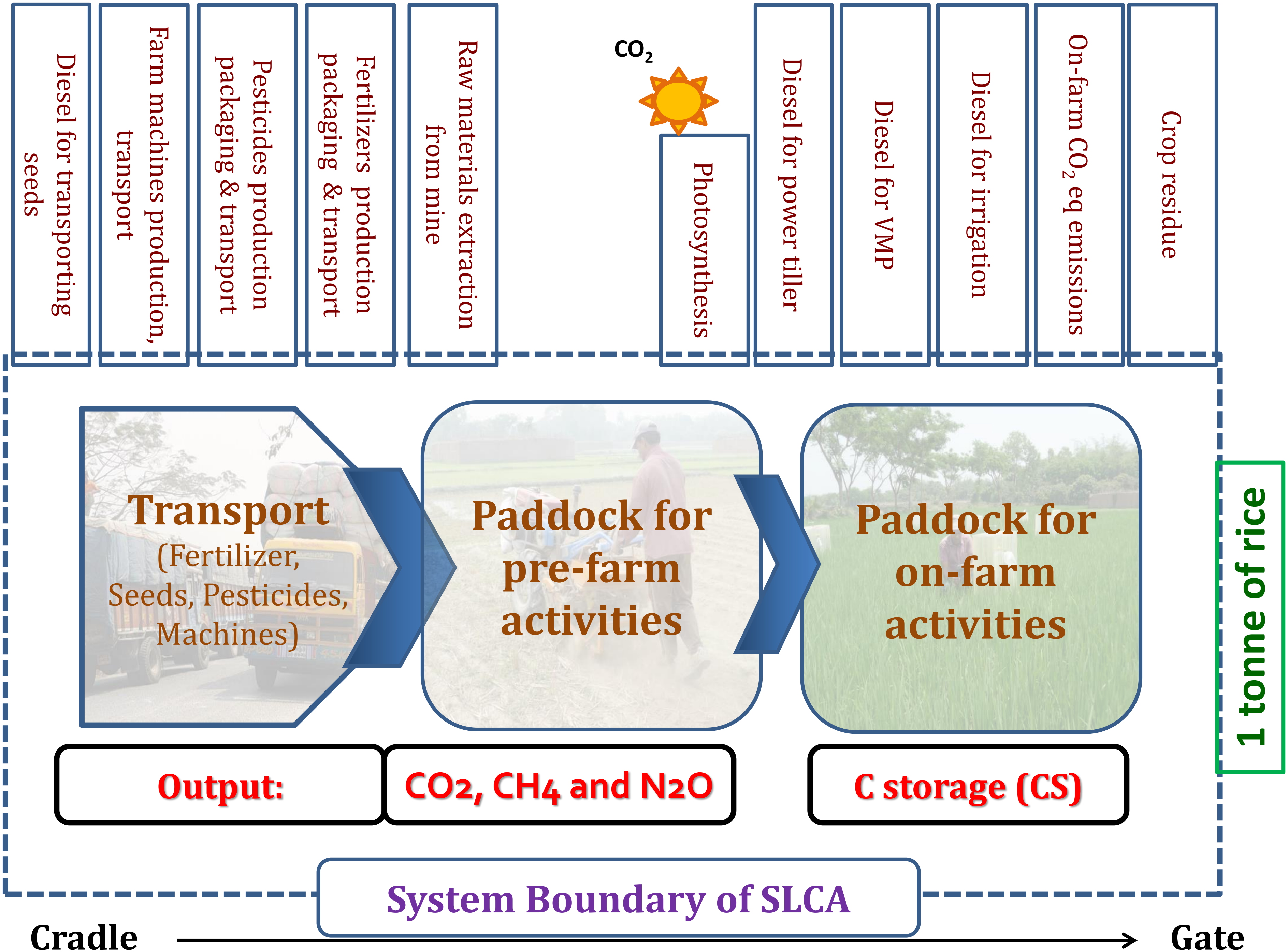
Chamber - (30 cm length × 30 cm width × 60 cm height)

Chamber base - 31 cm  length × 31 cm width × 7 cm height,
Chamber groove - 1 cm × 2.5 cm (width × deep)

## Closed gas chambers for $CH_4$ and $N_2O$

60 cm length × 30 cm width × 100 cm height





Diesel for transporting seeds
Farm machines production, transport
Pesticides production packaging & transport
Fertilizers production packaging & transport
Raw materials extraction from mine
CO2
Photosynthesis
Diesel for power tiller
Diesel for VMP
Diesel for irrigation
On-farm CO2 eq emissions
Crop residue
Transport
(Fertilizer, Seeds, Pesticides, Machines)
Paddock for pre-farm activities
Paddock for on-farm activities
1 tonne of rice
Output:
CO2, CH4 and N2O
C storage (CS)
System Boundary of SLCA
Cradle
Gate

# SLCA for field paddy production

- goal and scope definition
- inventory analysis
- impact assessment and
- interpretation.

Greenhouse gas emissions calculated for the following practices:

- Conventional puddled transplanting with low residue retention (CTLR)
- Conventional puddled transplanting with high residue retention (CTHR)
- Non-puddle transplanting with low residue retention (NPLR)
- Non-puddle transplanting with high residue retention (NPHR)

# Life cycle inventory

## Pre–farm emissions

### Chemicals

- ✓ Fertiliser
- ✓ Pesticides
- ✓ Herbicides

### Farm machinery

- ✓ Plough/PT/VMP
- ✓ Harvester

### Transport

- ✓ Trucks
- ✓ Shipping

## On–farm emissions

- ✓ Farm machinery
- ✓ Soil

**Ref: Alam et al. 2016; Journal of Cleaner Production 112(5): 3977-3987**

# Impact assessment

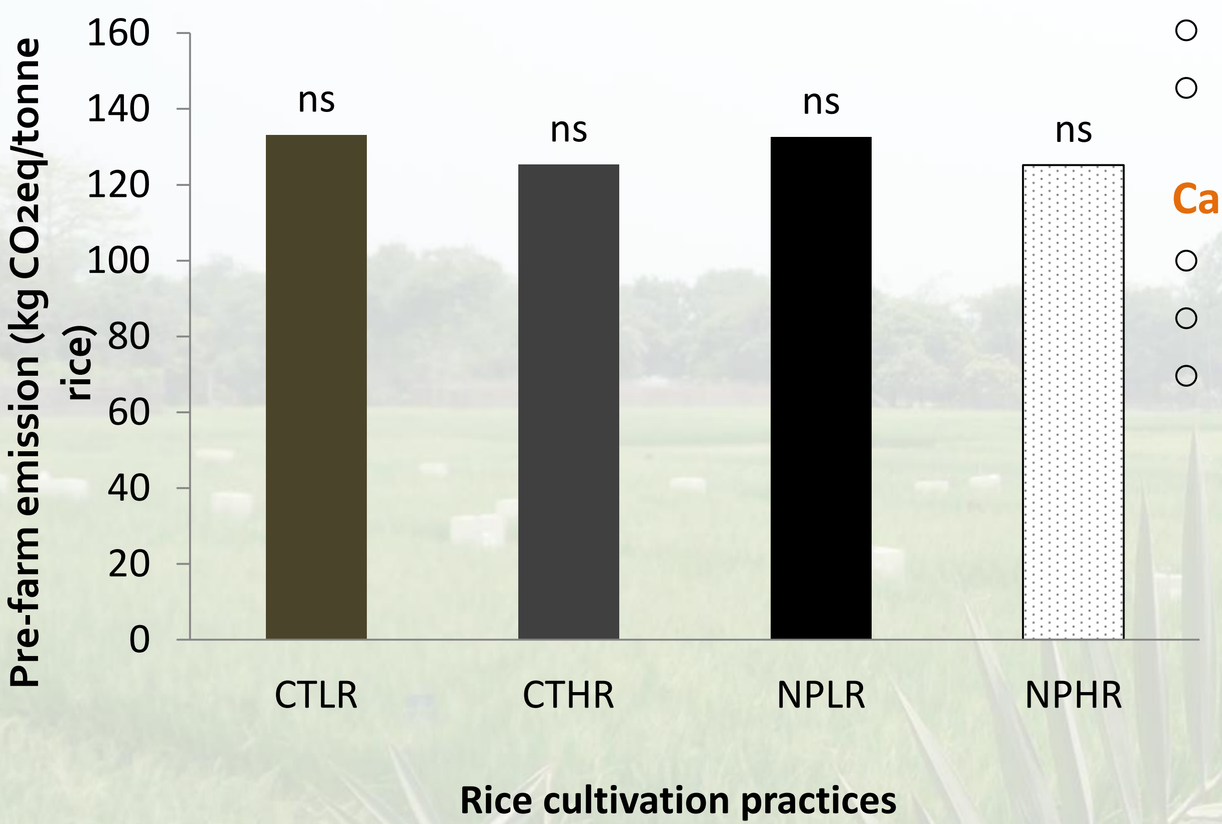
Global warming potential (GWP)

| Greenhouse gas | Time horizon | | |
|---|---|---|---|
| | 20 years | 100 years | 500 years |
| Carbon dioxide | 1 | 1 | 1 |
| Methane | 72 | 25 | 7.6 |
| Nitrous oxide | 289 | 298 | 153 |

Source: IPCC, 2013

# Results

## 2a. Pre-farm




- 7-11% of total LCA emission.
- Lower than any other paddy LCA in the world.

**Causes:**

- Lower level of input used
- Use of natural gas as a feed stock
- Light vehicles used

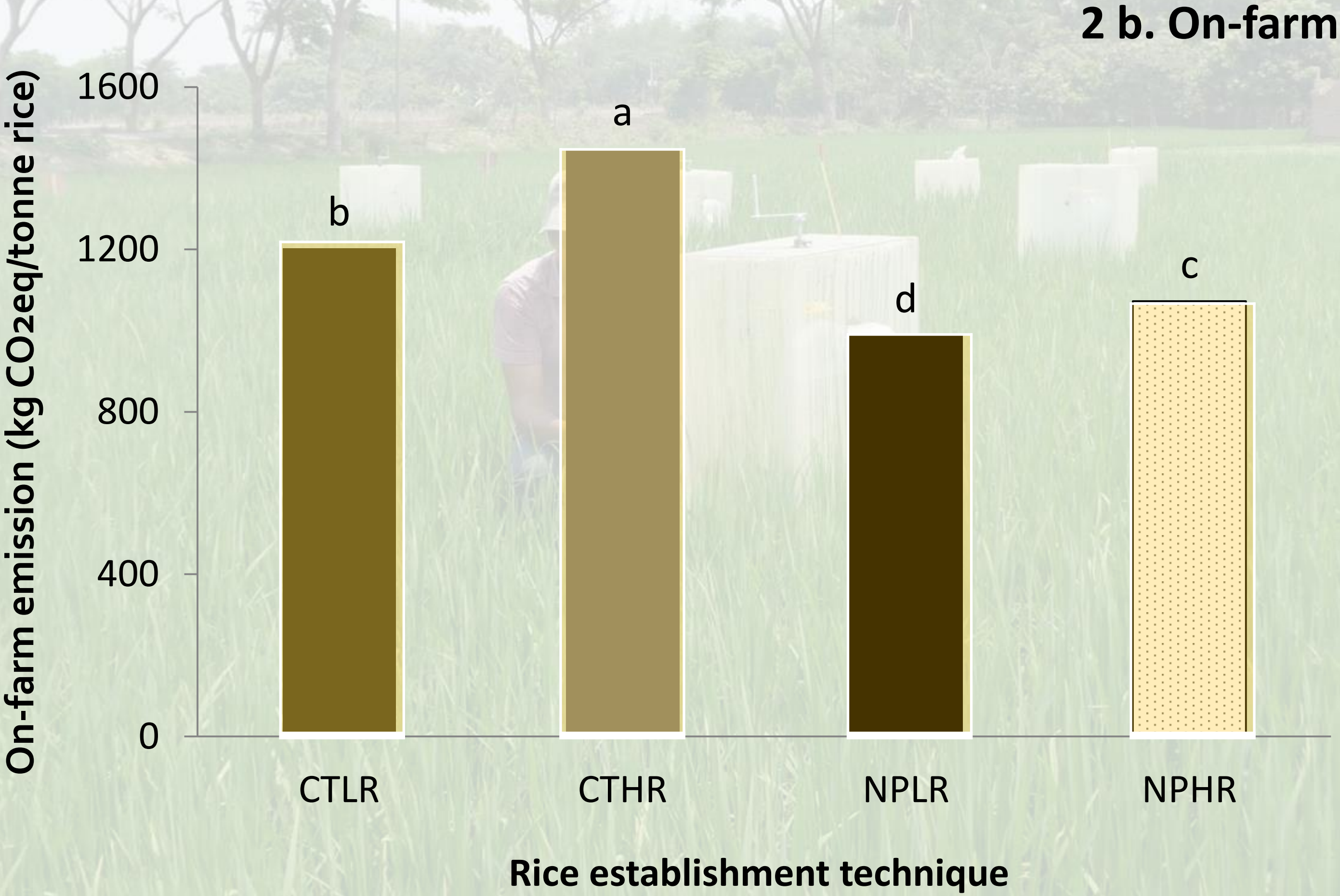
## Legend:

CT = Conventional puddled transplanting

NP = Non-puddle transplanting

HR = High residue retention (NPTHR)

LR= Low residue retention (NPTLR)


2 b. On-farm
On-farm emission (kg CO2eq/tonne rice)
1600
1200
800
400
0
a
b
d
c
CTLR
CTHR
NPLR
NPHR
Rice establishment technique

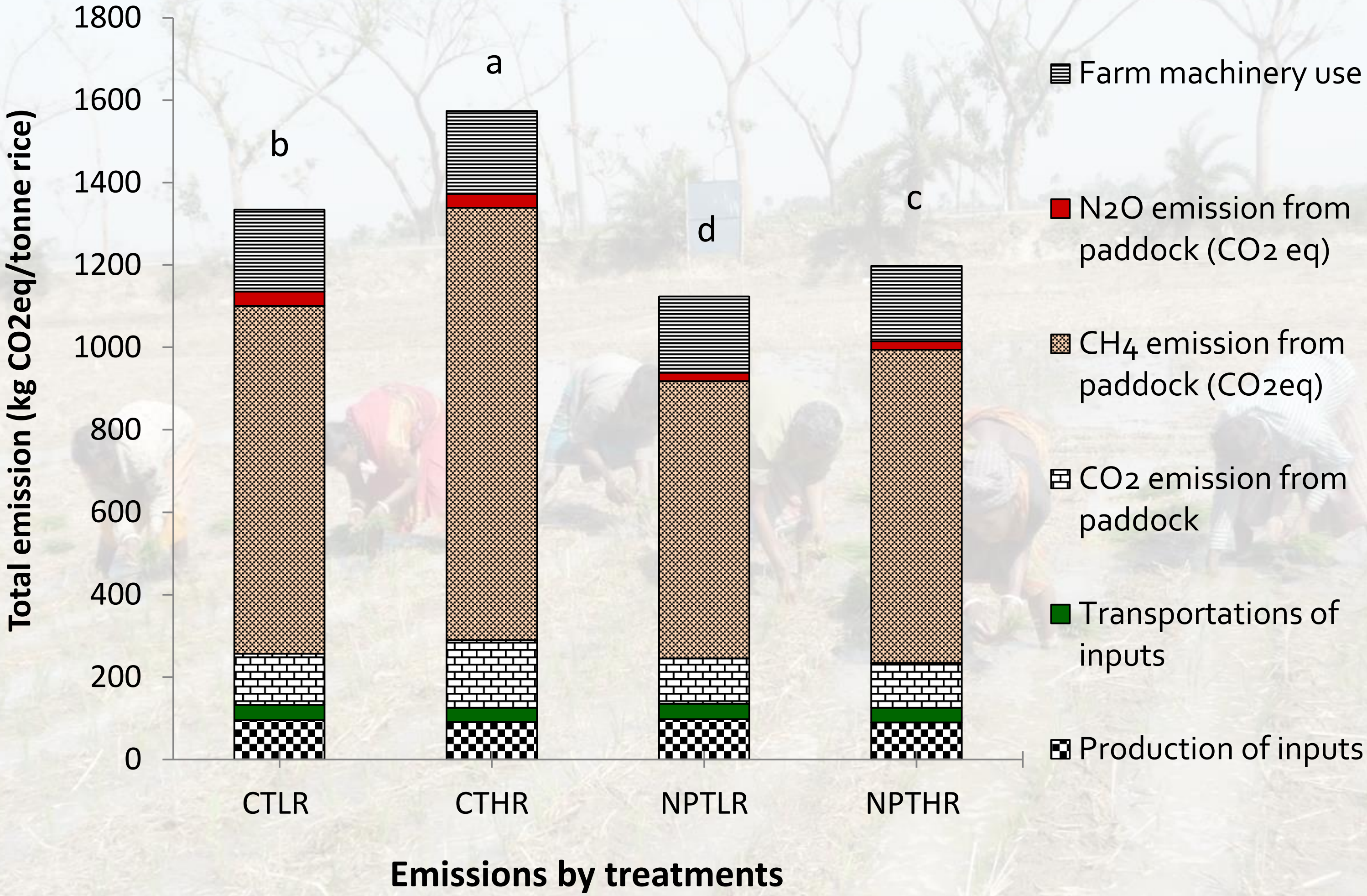
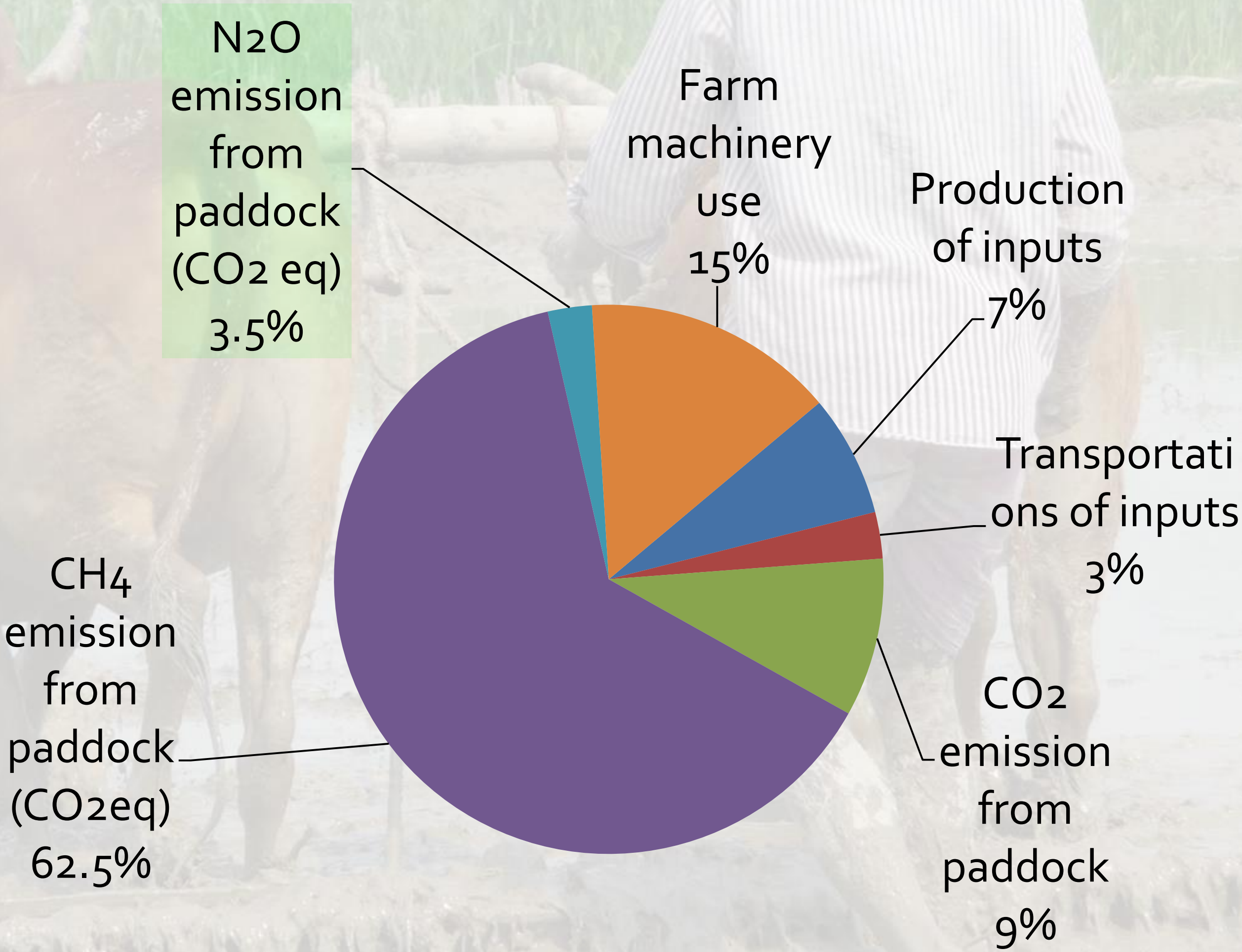
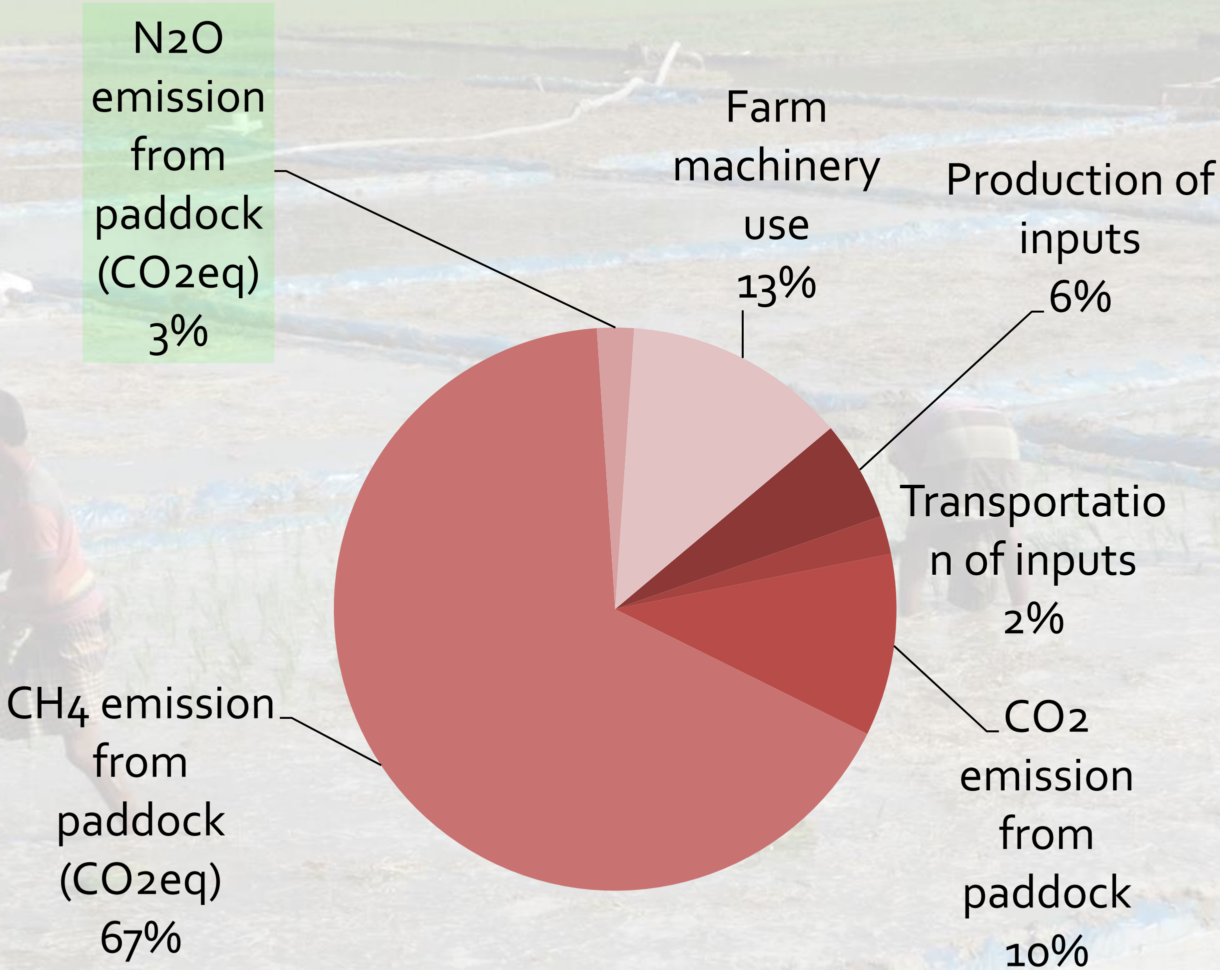



Fig. 2c. Total emissions showing contributions from different sources.

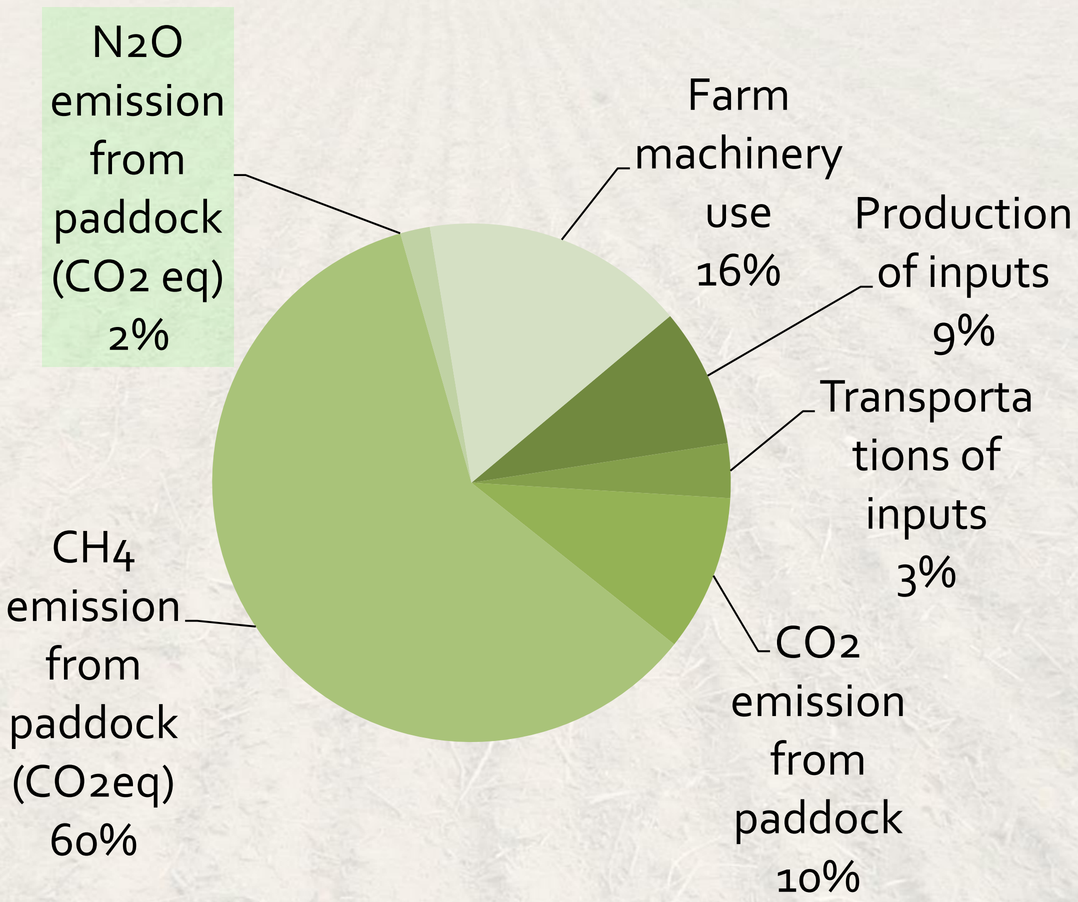
# CTLR (100 years time horizon)



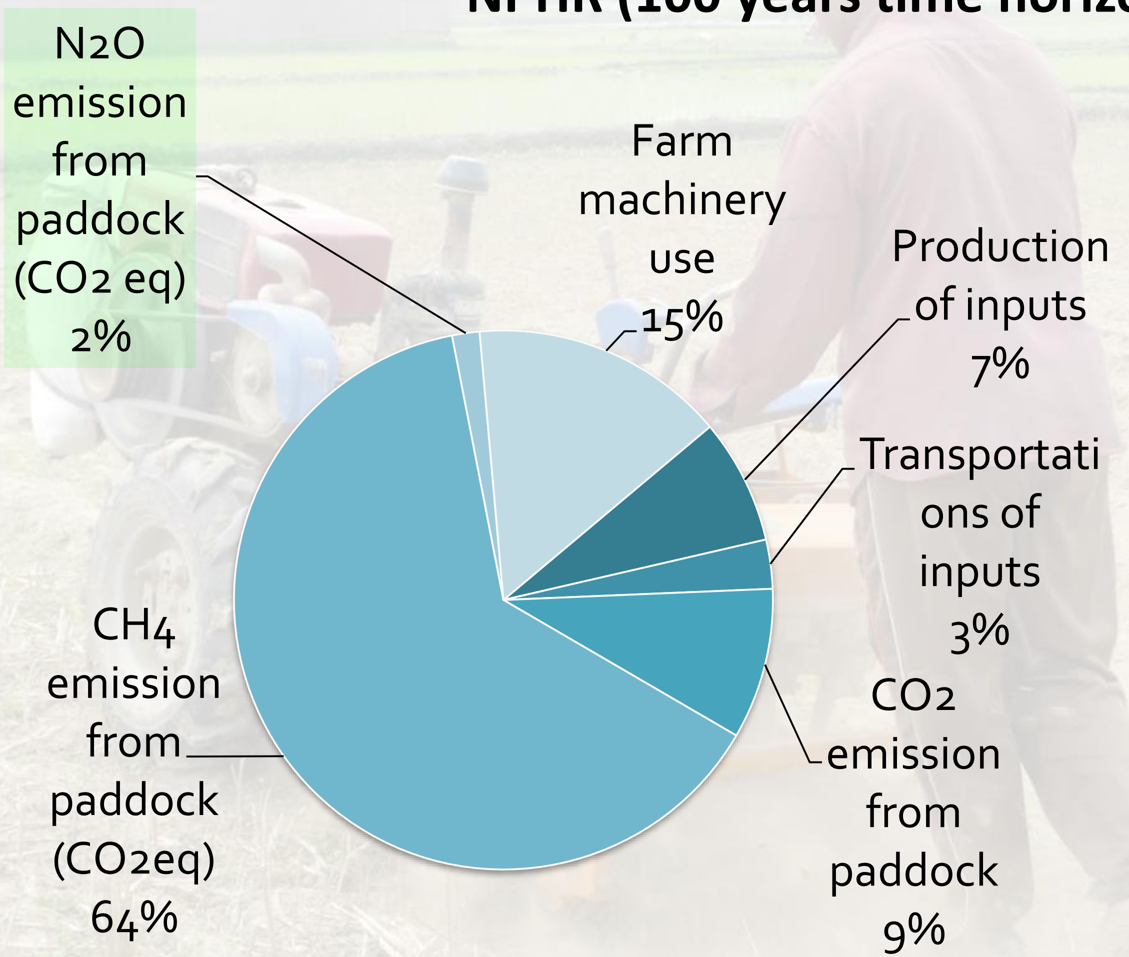
# CTHR (100 years time horizon)

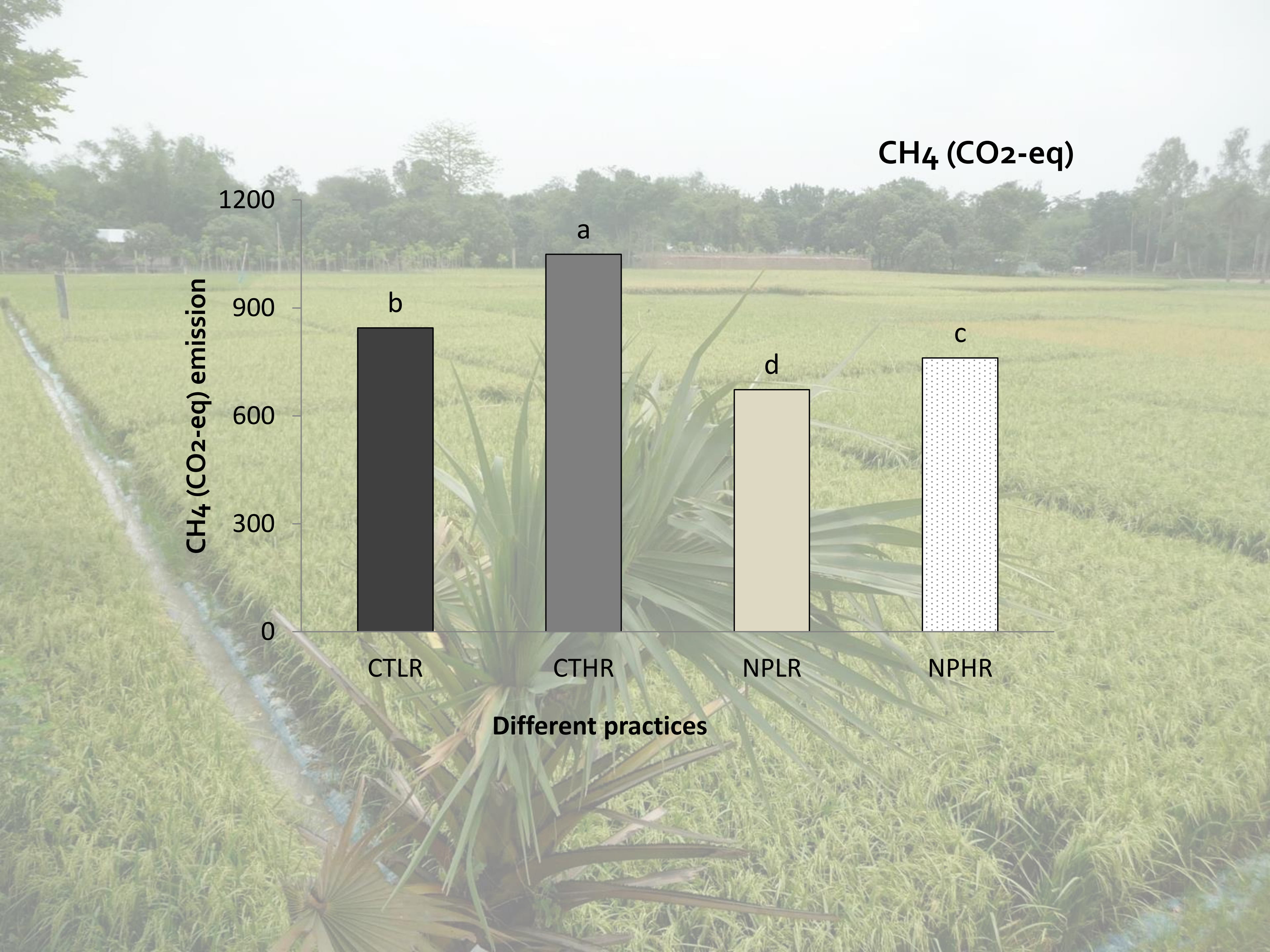


# NPLR (100 years time horizon)



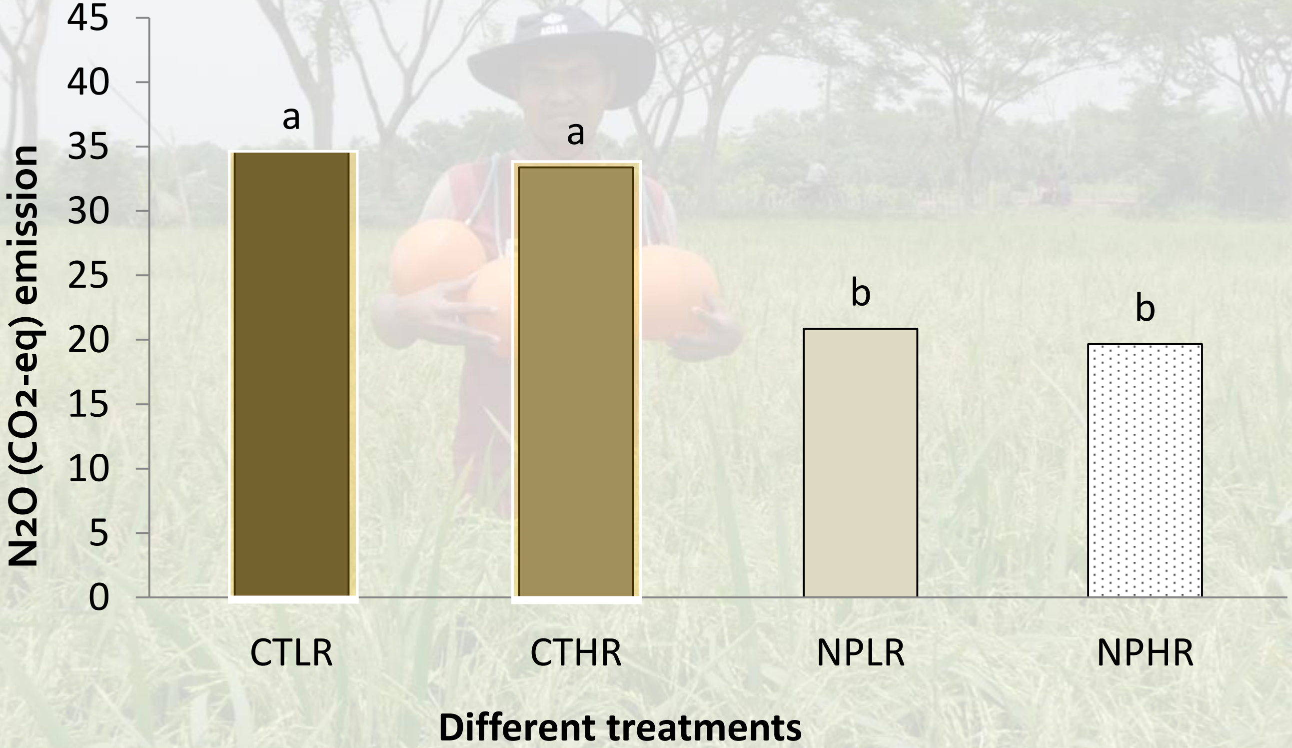
# NPHR (100 years time horizon)



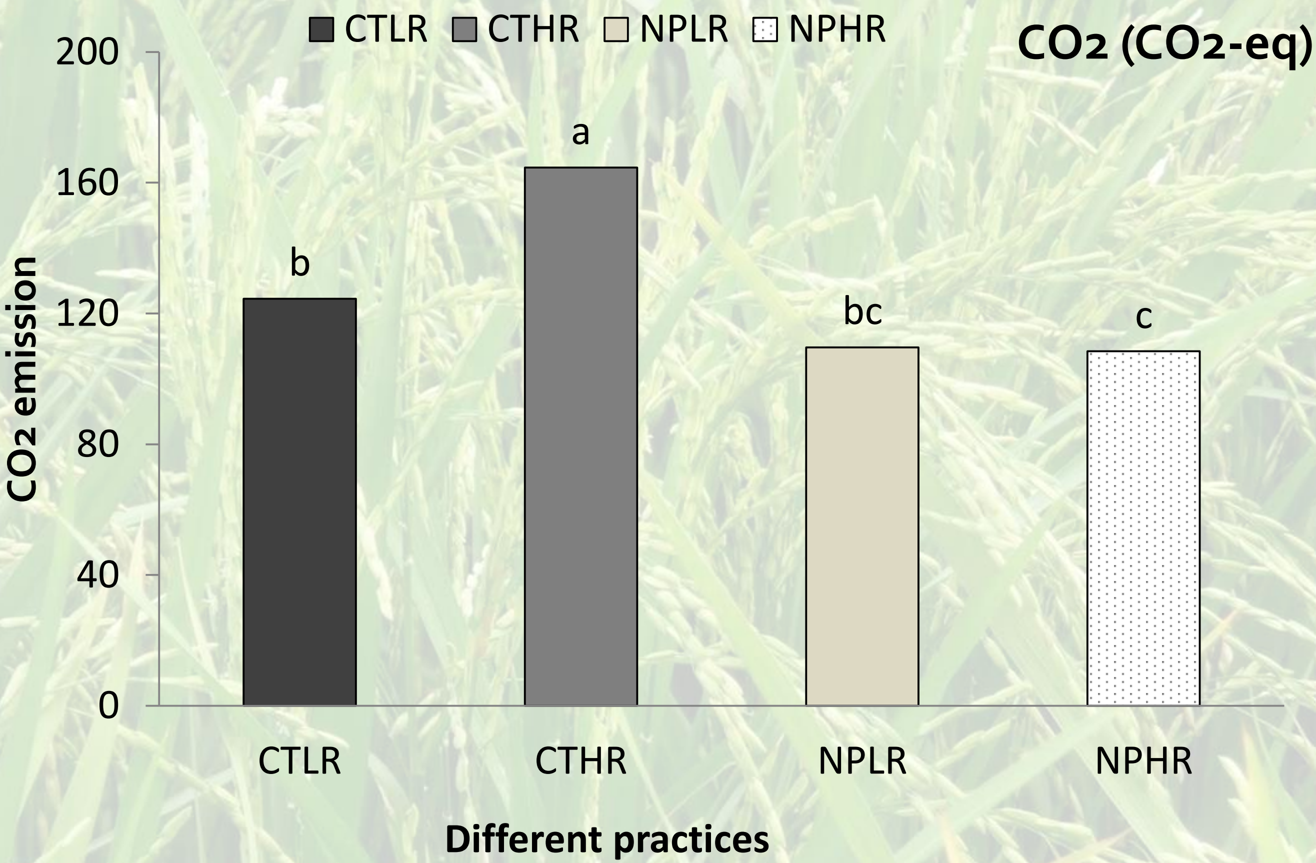


CH4 (CO2-eq)
1200
900
600
300
0
CH4 (CO2-eq) emission
a
b
c
d
CTLR
CTHR
NPLR
NPHR
Different practices

## $N_2O$ ($CO_2$-eq)



45
40
35
30
25
20
15
10
5
0
N2O (CO2-eq) emission
a
a
b
b
CTLR
CTHR
NPLR
NPHR
Different treatments



CO2 (CO2-eq)
CTLR
CTHR
NPLR
NPHR
200
160
120
80
40
0
CO2 emission
b
a
bc
c
CTLR
CTHR
NPLR
NPHR
Different practices

# Conclusions

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- The CTHR emitted about 1.4 times more GHG emissions for one tonne rice than NPLR.
- Applying NPLR in the wetland rice system of the EGP can reduce GHG emissions to 1.1 tonne $CO_2$–eq tonne$^{-1}$ rice production.
- The on–farm stage contributed the highest portion of the total GHG emissions.
- $CH_4$ was the predominant GHG from 1 tonne of rice production.
- $N_2O$ emission contributing only 2-3.5 % of the total LCA GHG.
- We recommend additional SLCA studies for all the crops of the cropping system.

Ref: Alam et al. 2016; Journal of Cleaner Production 112(5): 3977-3987

# Acknowledgements

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Your patience appreciated
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