# Global Methane and Nitrous Oxide Emissions and Reduction Potentials in Agriculture

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# Outline

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- Model
  - Structure
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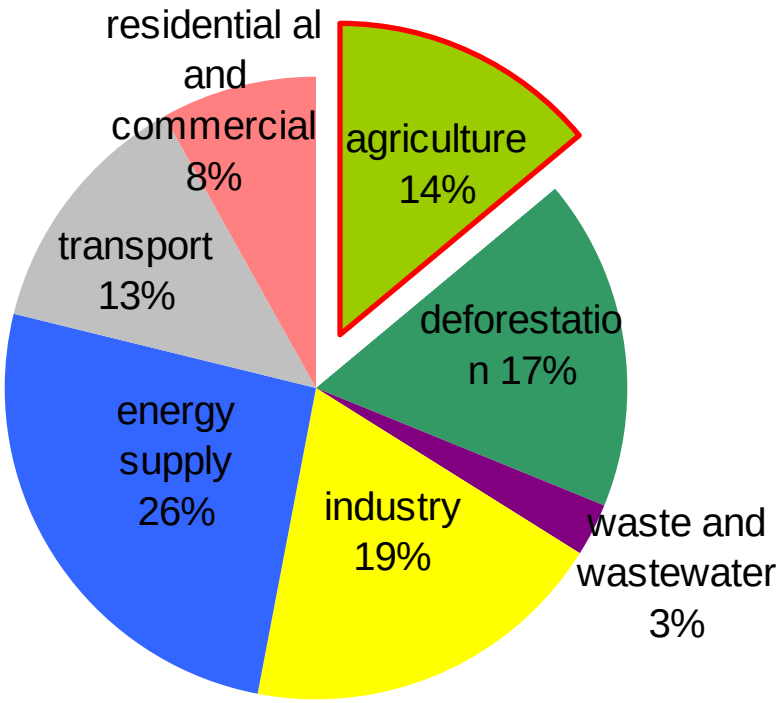
- Result

# Background

- Agriculture accounts for 14% of total GHG emission
- GHG reduction technology in agriculture
  - Have a high economic efficiency
  - Expected to play an important role

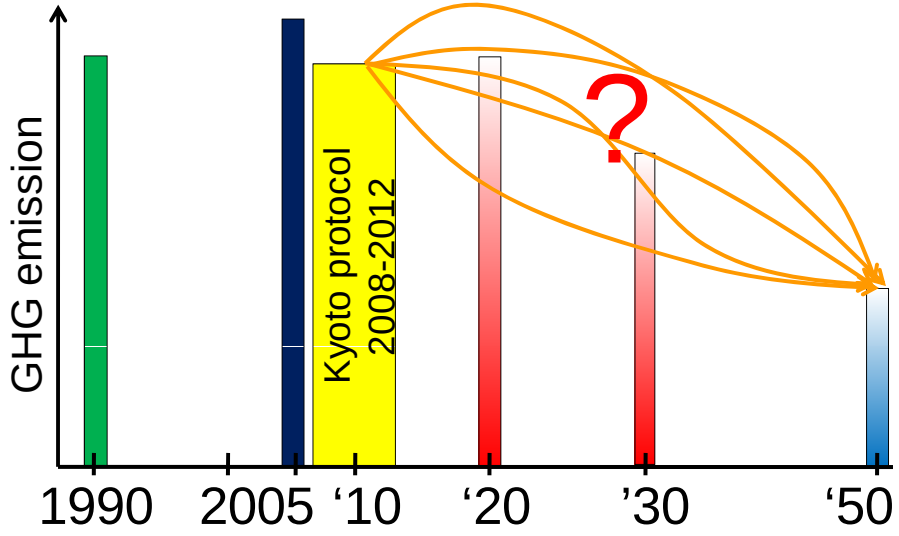



contribution ratio by Sector

# Considering technology changing process

- Important to show a feasible and realistic path.
- Long time gap between Kyoto target in 2008-2012 and a long-term target in 2050

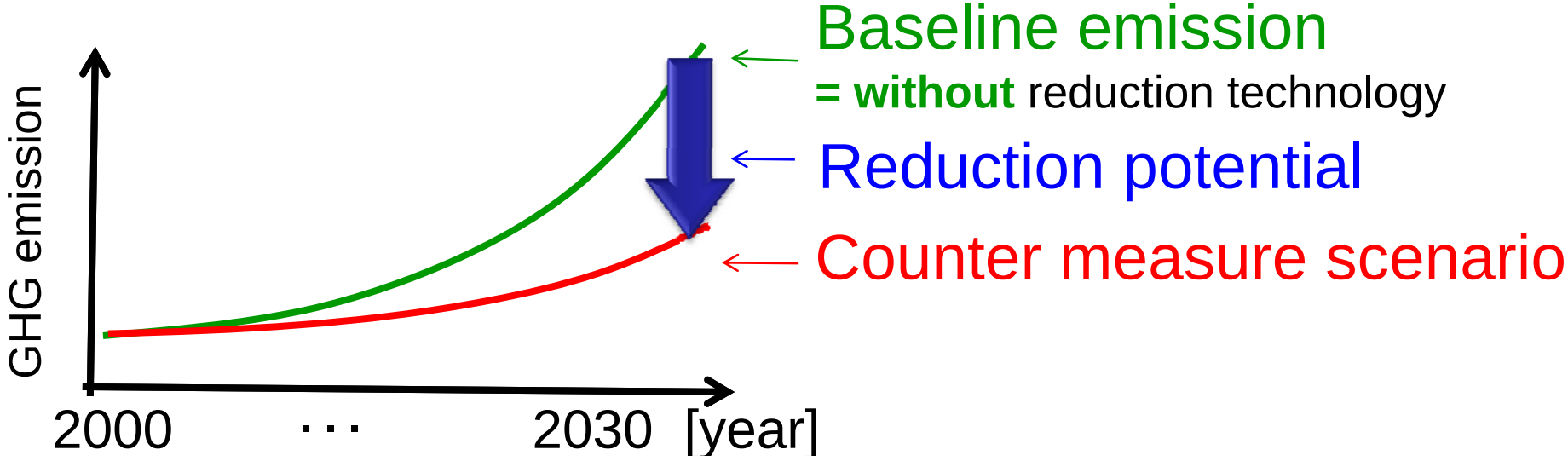
- It is necessary to consider a historical change of technology's stocks.
- In many researches, however ,the historical change of technology stock is NOT considered.



# Objectives

(1) Estimation and evaluation of global GHG emission and reduction potentials in agriculture in 2000-2030

(2) Specification of effective technologies, regions and emission sources with high reduction potentials



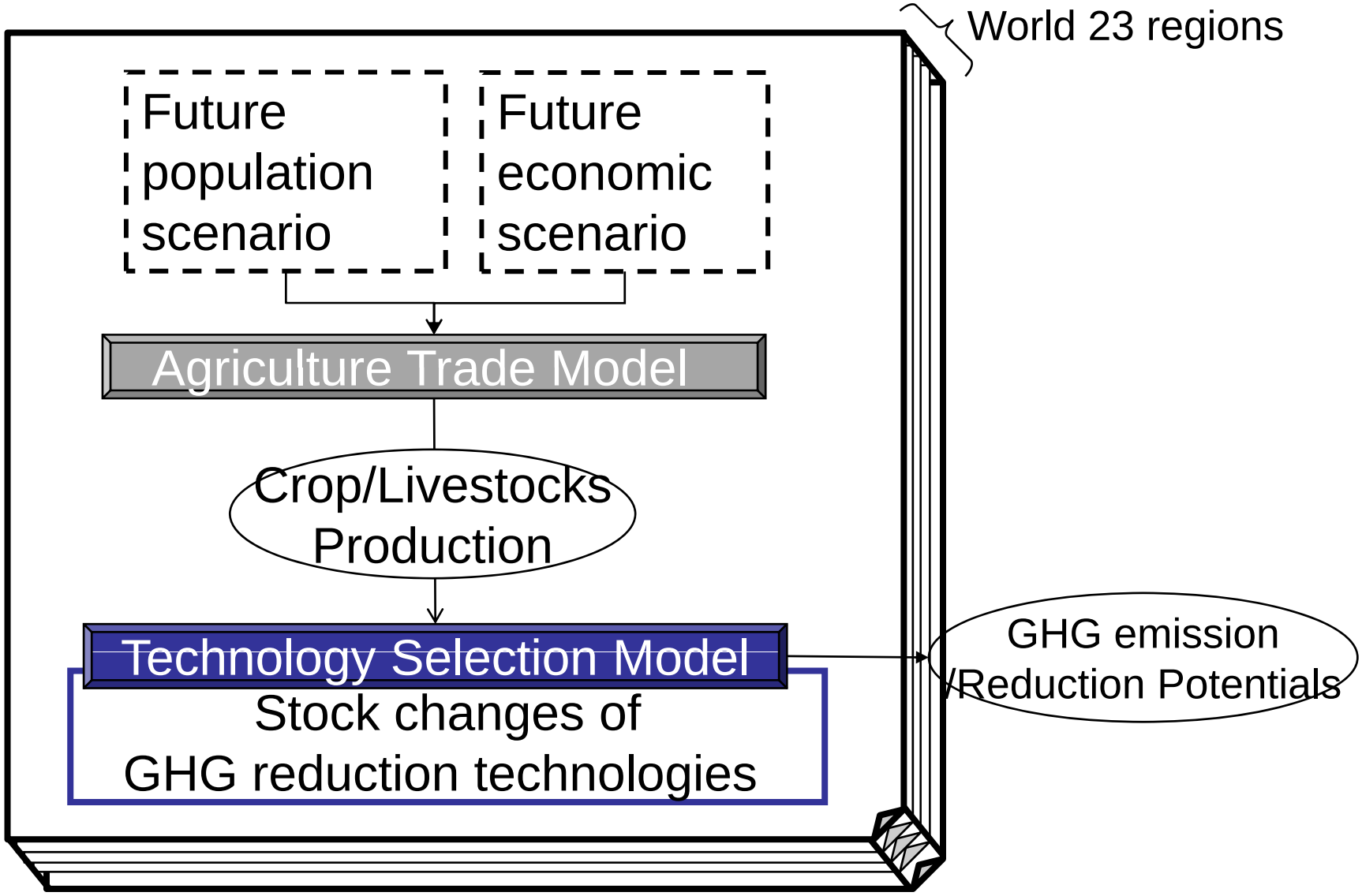
# Emission sources

| Emission Sources | Gases |
|---|---|
| Enteric fermentation | $CH_4$ |
| Manure management | $CH_4$, $N_2O$ |
| Cropland and Soils | $N_2O$ |
| Rice paddy | $CH_4$, $N_2O$ |



# Methodology

- Model consists of 2 sub-models



# Technology Selection Model

- Dynamic model
- How many introduced/working technologies are determined by people's selection;

➡ Optimization problem
to minimize total cost for 30 years.

# Technology Selection Model

## Objective function

$$\text{Total Cost} = \sum_{t}\sum_{r}\sum_{i}\sum_{l}\left\{\begin{array}{l}\text{Initial Cost}_{r,t,i,l}\\ +\text{O\&M Cost}_{r,t,i,l}\\ +\text{Emission Tax}_{r,t,i,l}\end{array}\right\} \rightarrow \text{Min.}$$

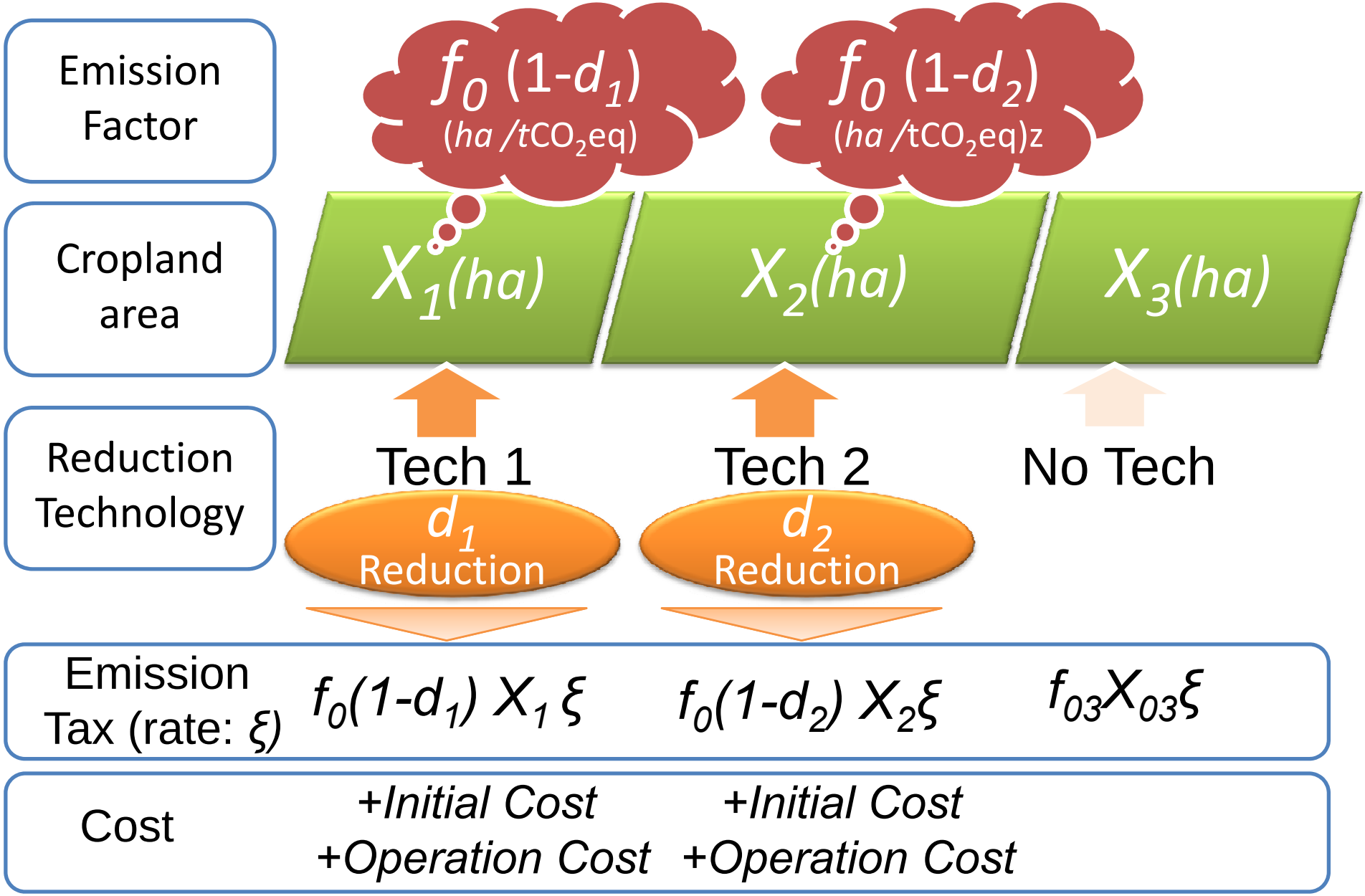
$$\left\{\begin{array}{l} r : \text{region}\\ t : \text{year}\\ i : \text{a kind of cropland/ livestock}\\ l : \text{technology}\end{array}\right.$$

# Technology Selection Model

$$GHG\ Emission_{r,t} = \sum_{i}\sum_{l}\left( X_{r,t,i,l} \cdot f_{0r,i,l} \cdot (1-d_l) \right)$$

$$\begin{cases} r : \text{region} \\ t : \text{year} \\ i : \text{a kind of cropland/ livestock} \\ l : \text{technology} \\ X_{r,t,i,l} : \text{activity of } i, \text{ with technology } l, \text{ region } r, \text{ year } t \\ f_{0r,i,l} : \text{emission factor} \\ d_l : \text{reduction ratio of technology } l, \text{ region } r \end{cases}$$

# Amounts of Technology and Cost



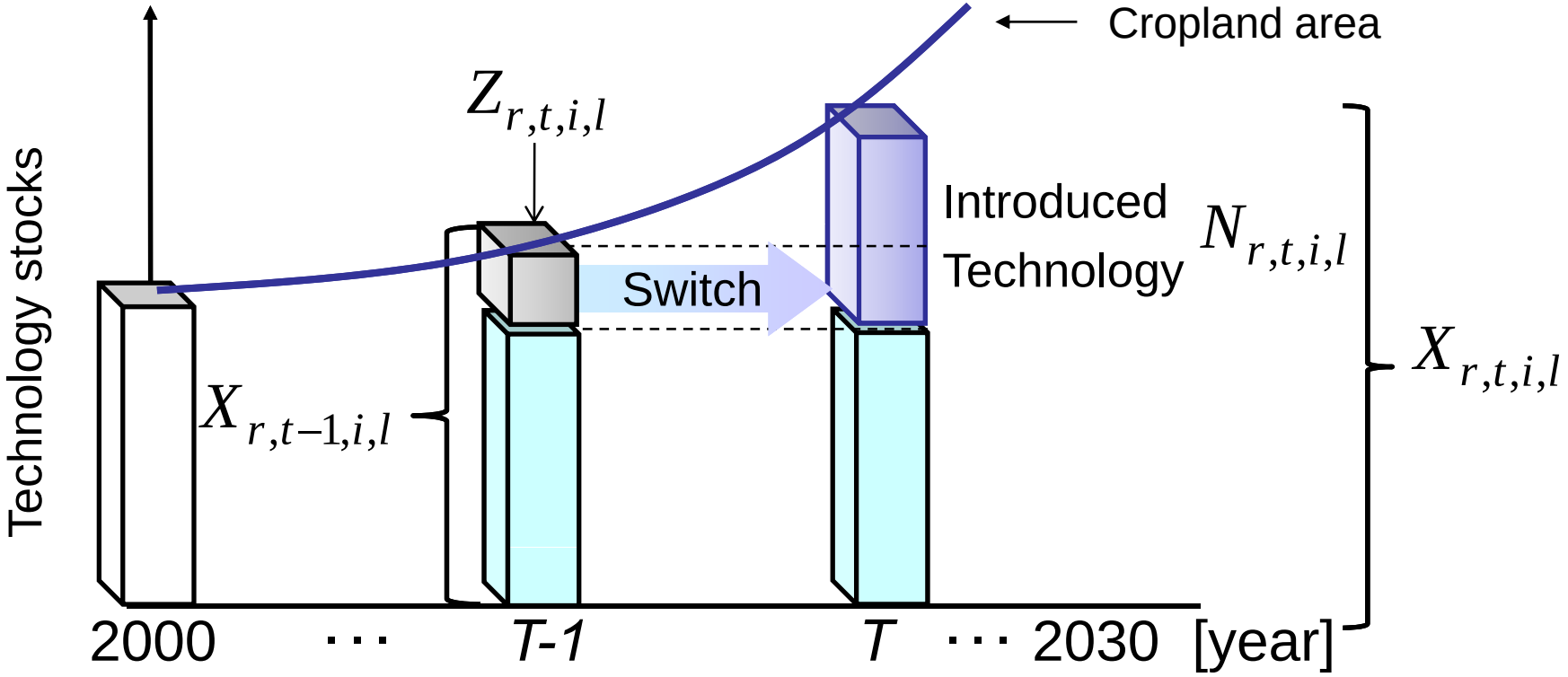
# Technology Stock Change

$$X_{r,t,i,l} = X_{r,t-1,i,l} - Z_{r,t,i,l} + N_{r,t,i,l}$$

$X_{r,t,i,l}$ : a ctivity $i$, with technology $l$, region $r$, year $t$

$Z_{r,t,i,l}$ : a ctivity $i$ which stop using technology $l$

$N_{r,t,i,l}$ : a ctivity $i$ which s tart using technology $l$



# Reduction technology

| Rice Paddy | Cropland and Soils |
|---|---|
| Replacing ferilizers with ammonium sulfate | Spreader maintenance |
| Midseason drainage | Fertilizer Free Zone |
| Off-season straw | Optimize distribution geometry |
| Shallow flooding | Nitrogen inhibitor |
| Upland rice | Convert fertilizational tillage to no-tillage |
| Addition of Phosphogypsum | Split fertilization |
| Rice Straw Compost | Reduce fertilization to 70% |
| Direct Wet Seeding | Reduce fertilization to 80% |
| Alternative flooding/Drainage | Reduce fertilization to 90% |

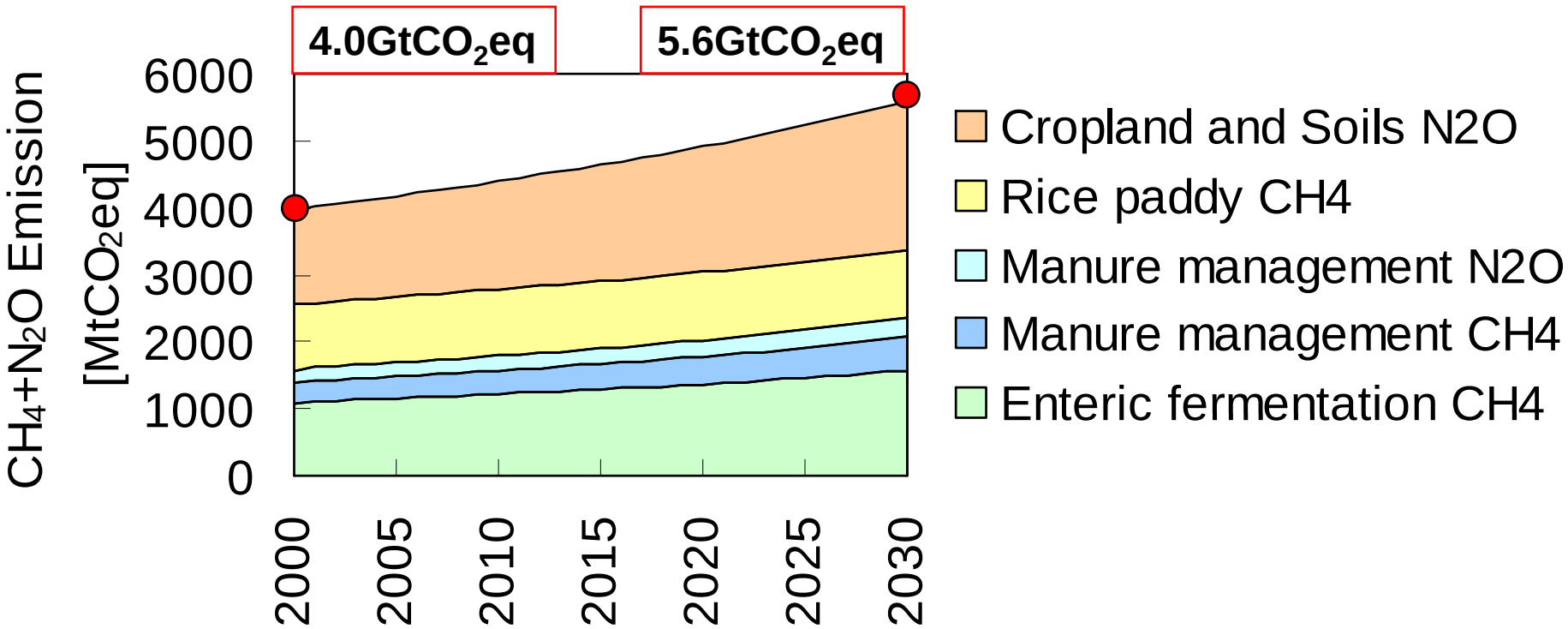
| Manure Management | Enteric Fermentation |
|---|---|
| Anaerobic Digestion -Centralised plant | Pribiotics |
| Anaerobic Digestion -Farmscale plant | Propionate precursors |
| Covered lagoon | |
| Daily spread of manure | |
| Slowing down anaerobic decomposition | |

* IPCC(2007), USEAP(2006), Graveland et al.(2002), Graus et al.(2004) and Bates(1998, 2001)

# Result

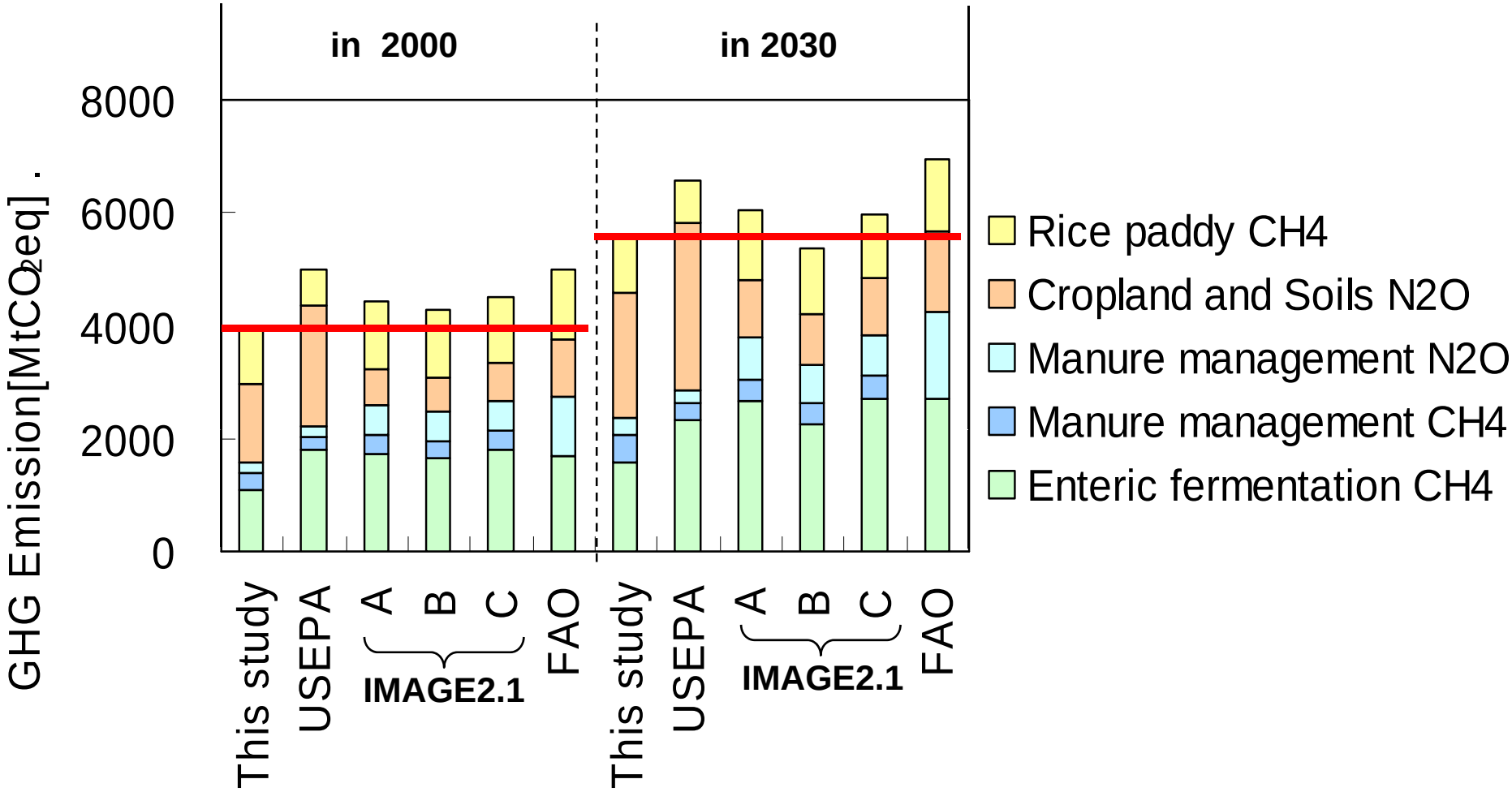
# Baseline Emission in 2000-2030

- World GHG emission will increase by 1.4 times by 2030.
- Emission from livestocks will increase at high growth rate.
- Emission from rice paddy will decrease.



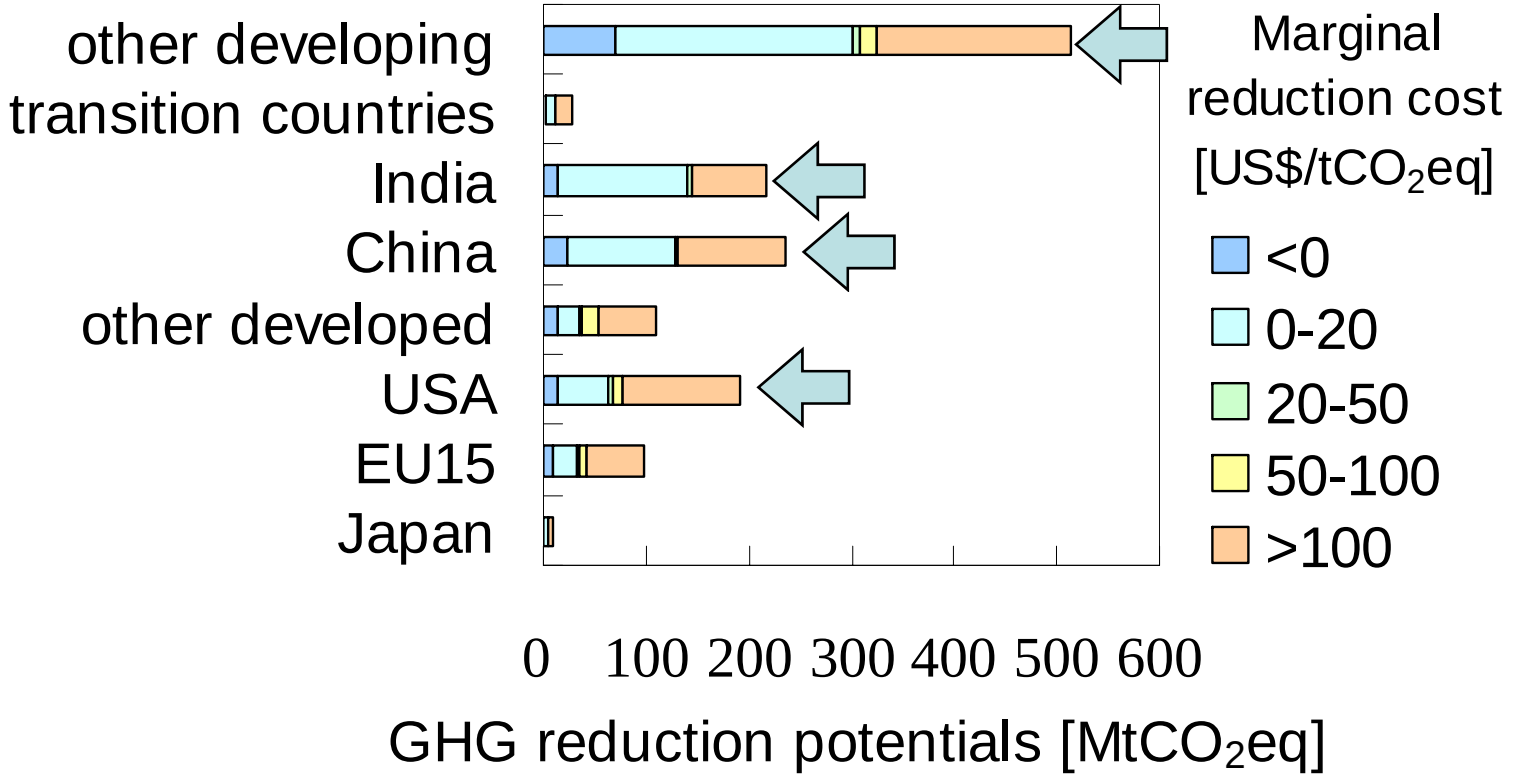
# Comparison with other estimates

This study's result is comparable to other estimates.

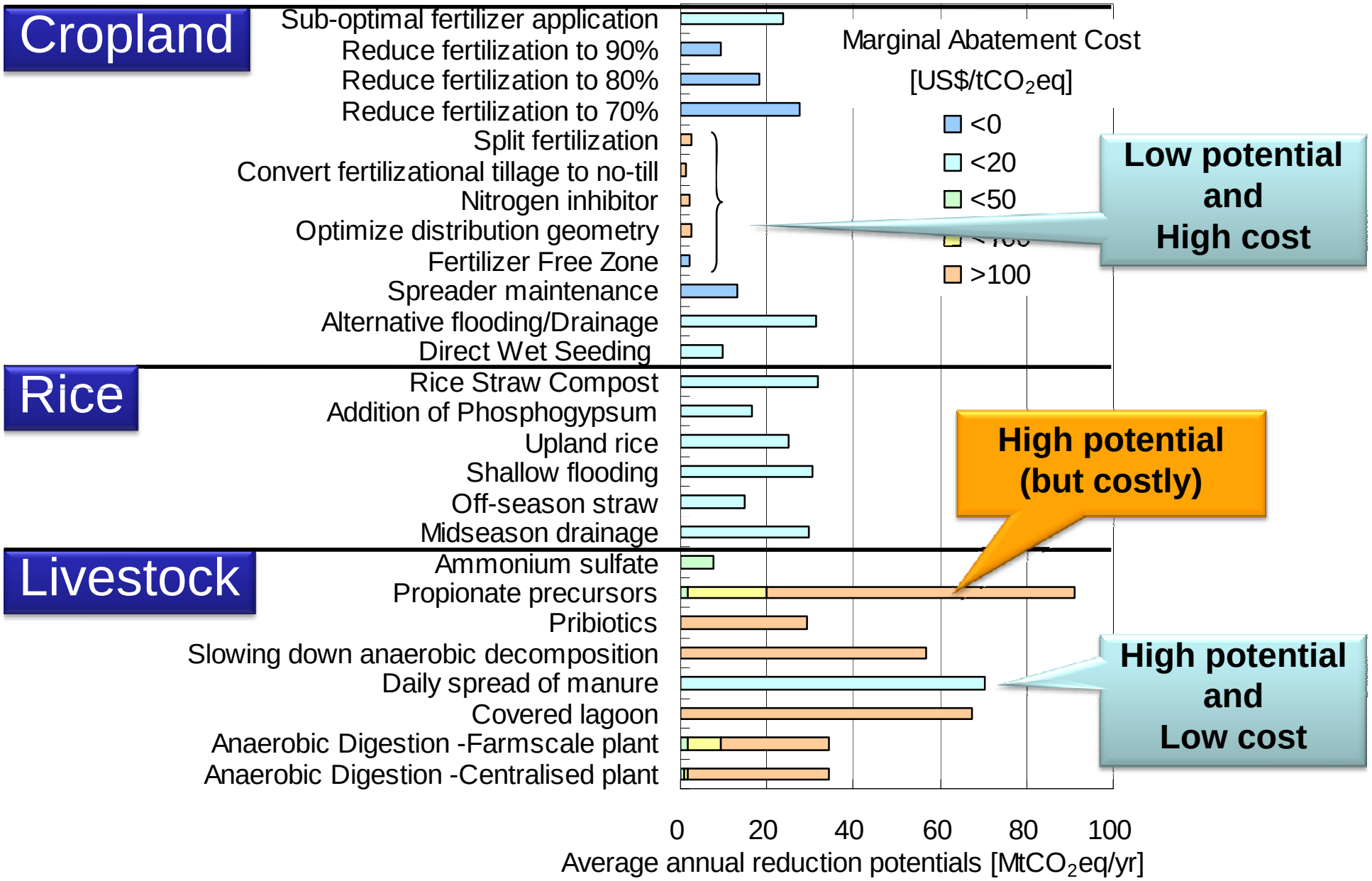


# Where is Effective Region?
## In 2030

- Reduction Potential in China, India and USA is large.
- GHG reduction takes low costs in these regions.



# What is Effective Technology ?



# Which is Effective Source?

## In 2030

| Reduction Potentials [$MtCO_2eq$] | Marginal Abatement Cost [US$/$tCO_2eq$ | | | | |
|---|---|---|---|---|---|
| Emission sources | <0 | <20 | <50 | <100 | >100 |
| Enteric fermentation $CH_4$ | 0 | 0 | 3 | 41 | 255 |
| Manure management $CH_4$ | 0 | 95 | 98 | 110 | 345 |
| Manure management $N_2O$ | 0 | 56 | 57 | 62 | 205 |
| Rice paddy $CH_4$ | 0 | 367 | 381 | 381 | 381 |
| Cropland and Soils $N_2O$ | 148 | 198 | 198 | 198 | 217 |
| Total | 148 | 716 | 737 | 793 | 1403 |

35% of total GHG emission from agriculture in 2000.

# Conclusion

I introduced a model to estimate GHG emissions and reduction potentials in agriculture. I specified effective technologies, regions and emission sources with high reduction potential.

- In 2030, the maximum global reduction potential is expected to be 1.4 $GtCO_2eq$(35% of emission in 2000).

- High reduction potentials:
  - Region: China, India and USA
  - Emission source: Rice paddy
  - High reduction and Low cost technology: Daily spread of manure

Thank you for your attention !