

*turning knowledge into practice*

# Mitigation Potential and Costs for Global Agricultural Greenhouse Gas Emissions

*Robert Beach, RTI International*

*Benjamin DeAngelo and Steven Rose, US EPA*

*William Salas, Applied Geosolutions*

*Changsheng Li, University of New Hampshire*

*Stephen DelGrosso, Colorado State University*

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3040 Cornwallis Road  
Phone 1-919-485-5579

■ P.O. Box 12194 ■  
Fax 1-919-541-6683

Research Triangle Park, NC 27709  
e-mail [rbeach@rti.org](mailto:rbeach@rti.org)

[www.rti.org](http://www.rti.org)

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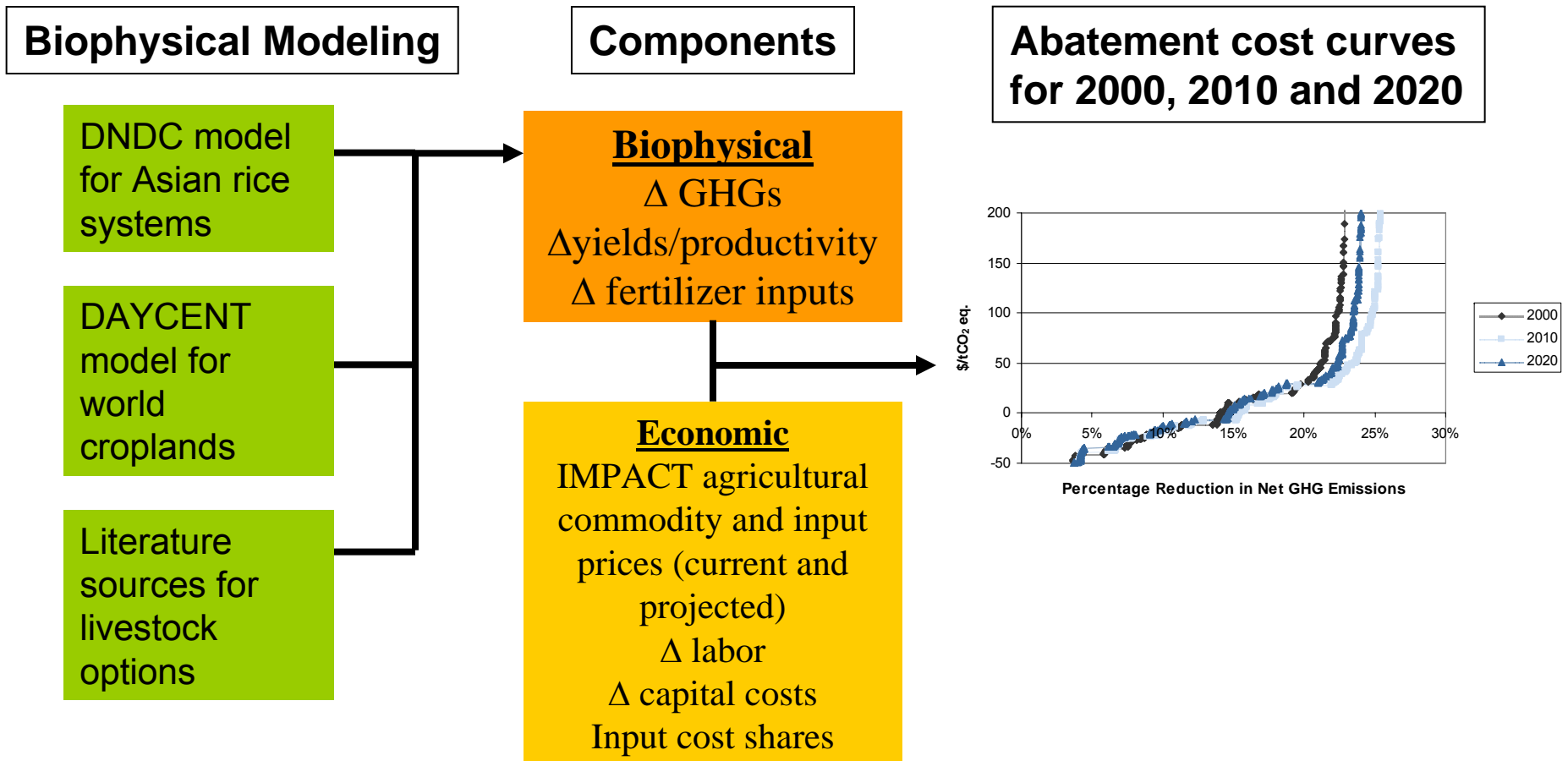
# Motivation

- Agriculture is a major contributor to global greenhouse gas (GHG) emissions
- Potential source of relatively low-cost mitigation
- Need for regional-level mitigation and cost estimates
  - Assess agriculture's comparative role in GHG mitigation across regions and time (e.g., Energy Modeling Forum)
- Provide globally consistent baseline and mitigation scenarios

# Challenges

- Spatial and temporal heterogeneity in biophysical and management conditions
- Multiple GHG fluxes and interactions between them
- Availability of region-specific cost data for mitigation options
- Estimation of regional adoption of mitigation options relative to baseline in response to incentives (e.g., carbon price)

# Enhancing Abatement Cost Estimation

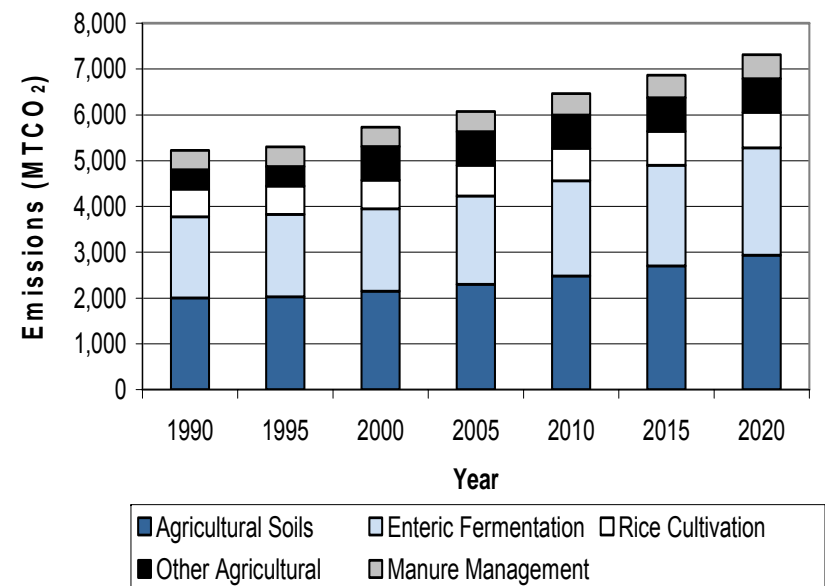


# Agricultural Emissions Characterization

- Focus on non-CO<sub>2</sub> gases, though changes in carbon sequestration are captured in process models
- 63% of global non-CO<sub>2</sub> GHG emissions
  - 84% of Nitrous Oxide (N<sub>2</sub>O)
  - 52% of Methane (CH<sub>4</sub>)
- 15% of global anthropogenic GHG emissions (in CO<sub>2</sub>eq) from non-CO<sub>2</sub> emissions alone
- Largest source in many developing countries
- Emissions are projected to increase significantly in the future due to increased demand for agricultural products and changing consumption patterns (e.g., increased meat consumption)

# Emission Sources

- Cropland soil management (N<sub>2</sub>O, soil C)
  - N<sub>2</sub>O largely related to use of N-based fertilizers
- Livestock
  - Enteric fermentation (CH<sub>4</sub>)
  - Manure Management (CH<sub>4</sub>, N<sub>2</sub>O)
    - ◆ Primarily CH<sub>4</sub> from anaerobic management
- Rice cultivation (CH<sub>4</sub>, N<sub>2</sub>O, soil C)
  - primarily CH<sub>4</sub> from flooded paddies, though N<sub>2</sub>O is important for certain growing conditions



# Cropland Soil Mitigation Options

- Cropland soils options generally focus on more efficient or reduced N-based fertilizer use
- Options considered
  - N-inhibitors
  - Split fertilization
  - Reducing N-fertilization to 70, 80, or 90 percent of baseline levels
  - Conversion to no-till cultivation

# Livestock Mitigation Options

- Enteric fermentation
  - Improve feed conversion efficiency
  - Increase animal productivity (bST, antibiotics)
  - Feed supplementation
  - Herd management (e.g. intensive grazing)
- Manure management
  - Anaerobic digesters

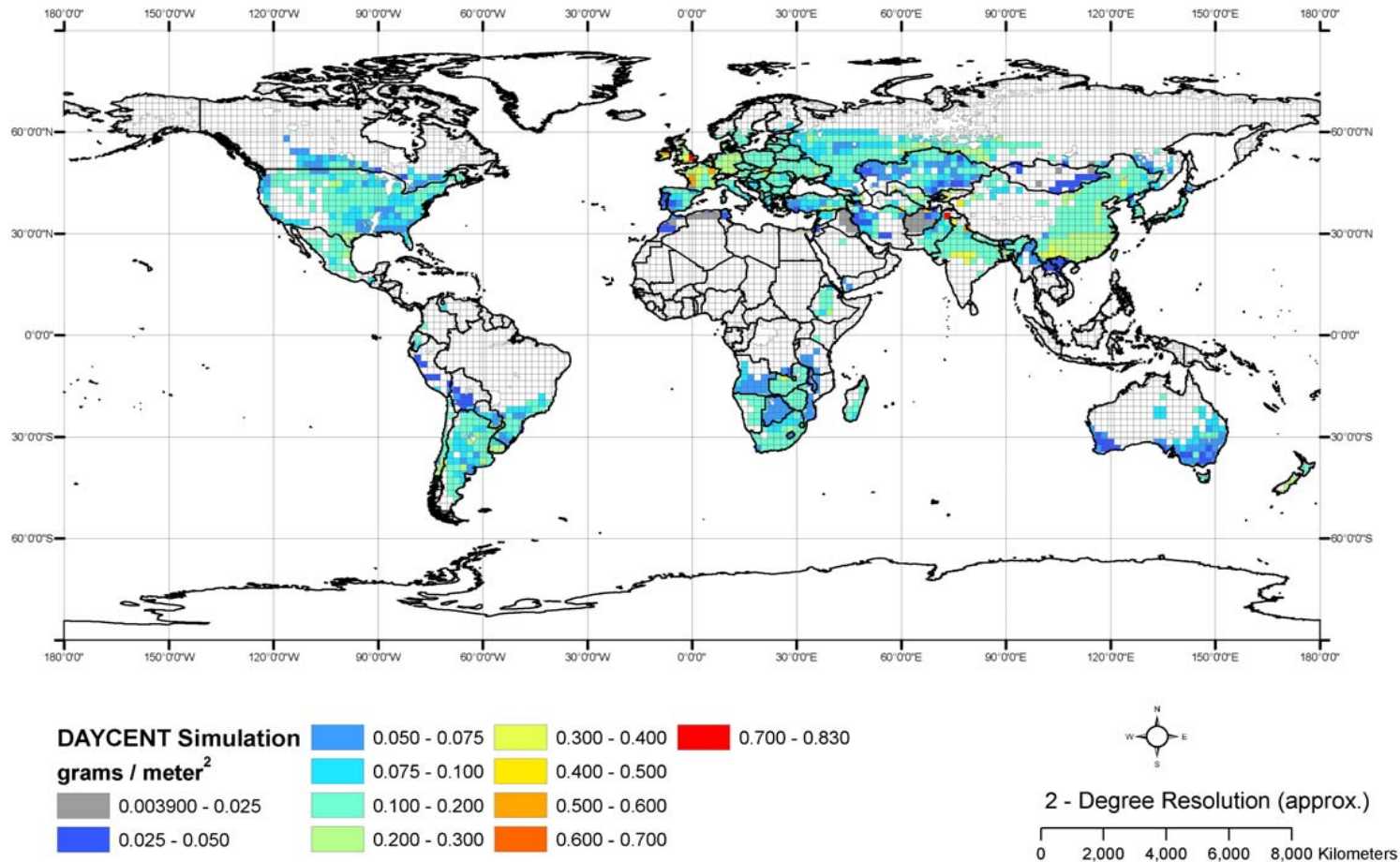
# Rice Cultivation Mitigation Options

- Mid-season drainage
- Shallow flooding
- Off-season addition of straw
- Switch to ammonium sulfate fertilizer
- Use slow-release fertilizer
- Switch to upland rice production

# Methods

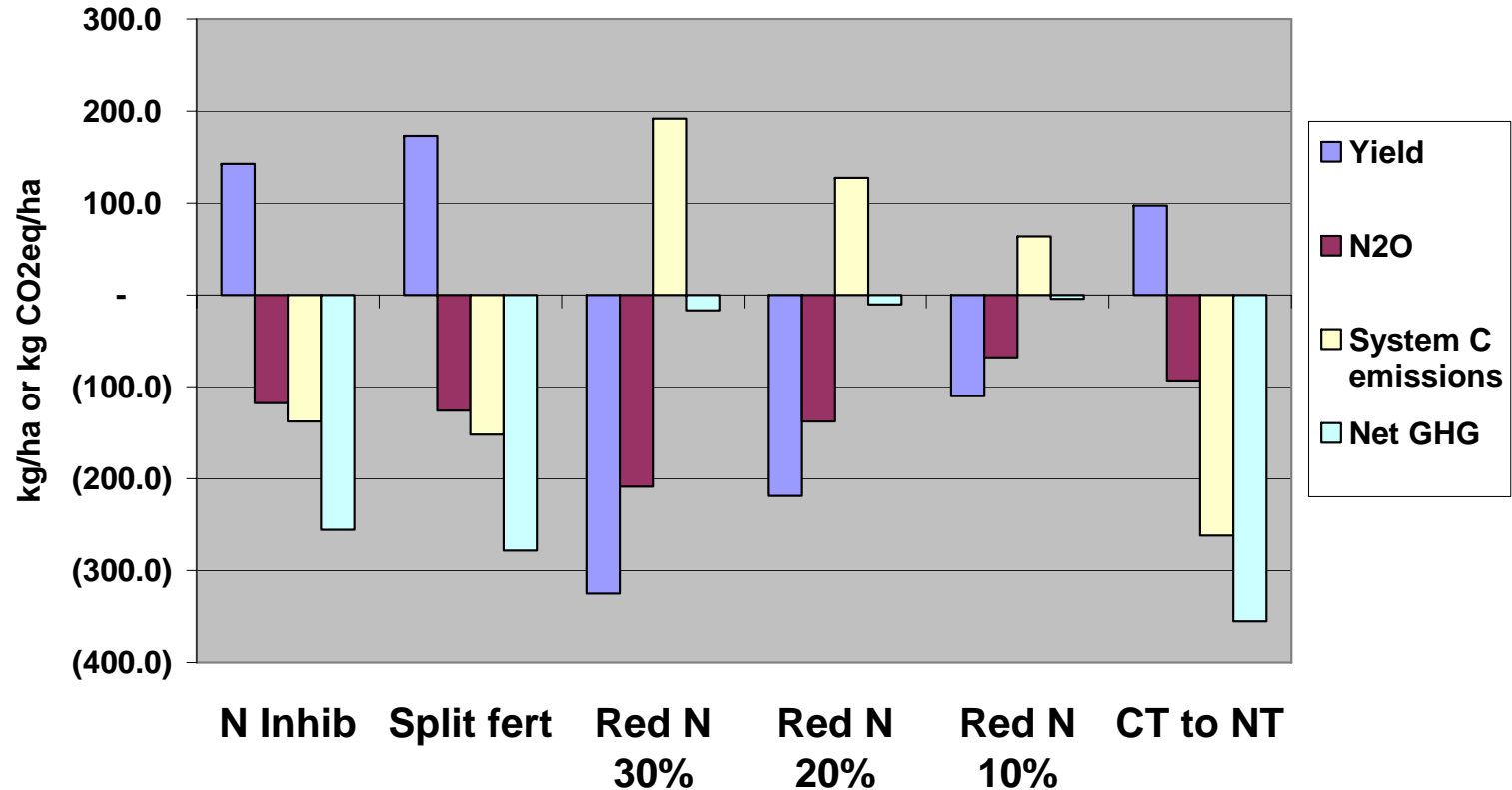
- DNDC model was used to estimate baseline and mitigation option emissions as well as yield and water resource changes for Asian rice systems
- DAYCENT model was used to estimate baseline and mitigation option emissions and yields for cropland soils for all world regions
- EPA (2006) baseline emission projections and estimated mitigation for various options from the literature were used for livestock
- Incorporated data on input and output prices and estimated input changes based on literature review to estimate \$/tCO<sub>2</sub> reduced by region and option

# DAYCENT-NCEP Global Simulation: Wheat N<sub>2</sub>O Emissions: 1991–2000



# Biophysical Response under Mitigation Alternatives

Responses to cropland management alternatives  
e.g., Argentina rainfed wheat 2010

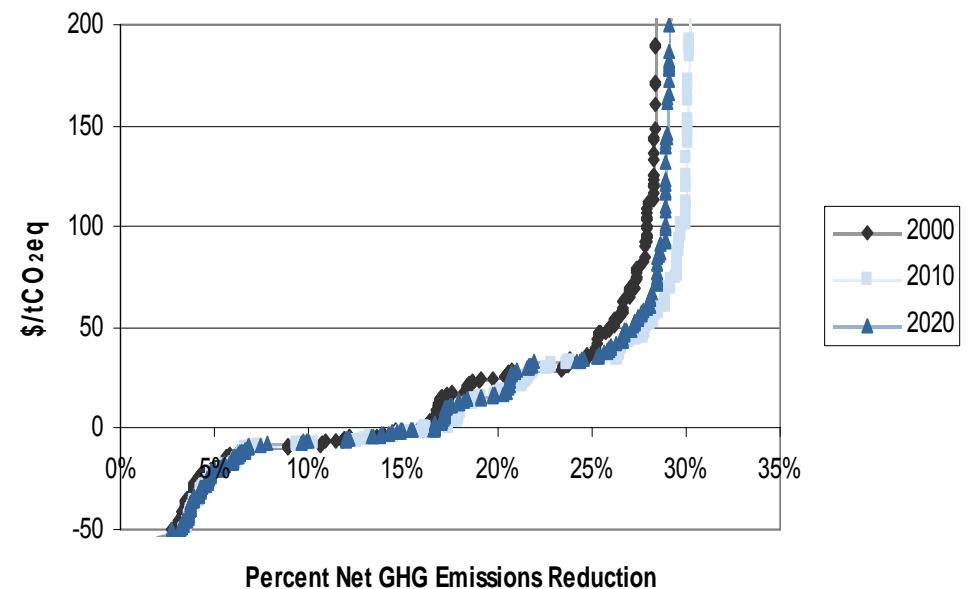


# Net GHG Effects of Conversion to Shallow Flooding in China, 2000-2020 (Li et al)

Waterbasin	Average Annual Reduction in Emissions	Proportion of National Area	Baseline (kg CO <sub>2</sub> eq/ha)	Average Annual Change (kg CO <sub>2</sub> eq/ha)	Average Annual Change (1000 tonnes CO <sub>2</sub> eq)	Proportion of National Reduction
Inland	52%	0.00	17,882	-9,213	-415	0.00
Haihe	58%	0.01	19,283	-11,248	-2,346	0.01
Songliao	46%	0.10	15,600	-7,116	-13,522	0.08
Huaihe	55%	0.13	23,113	-12,729	-30,546	0.18
Huanghe	58%	0.01	14,354	-8,349	-1,675	0.01
ZhuJiang	58%	0.17	43,436	-25,232	-78,540	0.46
Southeast	53%	0.08	33,614	-17,640	-26,681	0.16
Changjian	56%	0.48	3,374	-1,899	-16,825	0.10
Southwest	44%	0.02	7,625	-3,257	-996	0.01

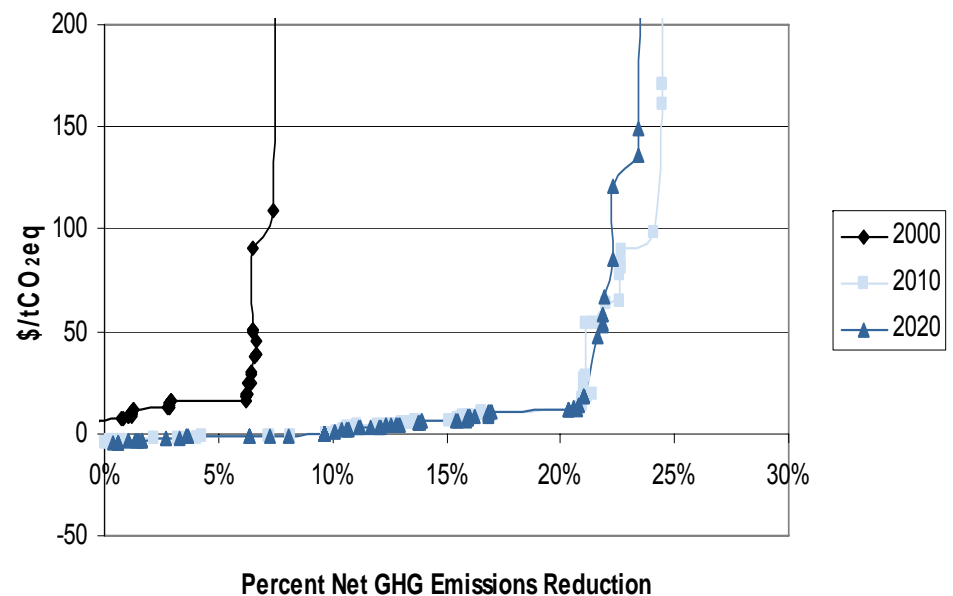
# Global Cost Curve for Soil Management

- Substantial potential for mitigation at less than \$40/tCO<sub>2</sub>eq
- Negative costs from options that reduce fertilizer use per unit of output while keeping yields at similar levels
  - Adoption barriers



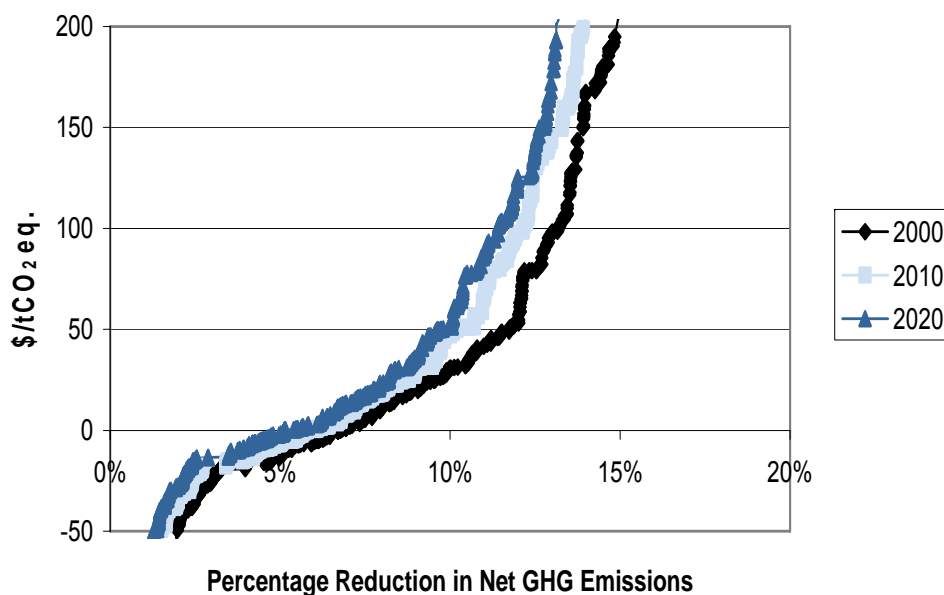
# Global Cost Curve for Rice Cultivation

- Large outward shift between 2000 and 2010, primarily due to dynamic impacts on soil C from several options
- Total global mitigation above 20% at about \$10/tCO<sub>2</sub>eq in 2010 and 2020
- Costs rise very rapidly after that point



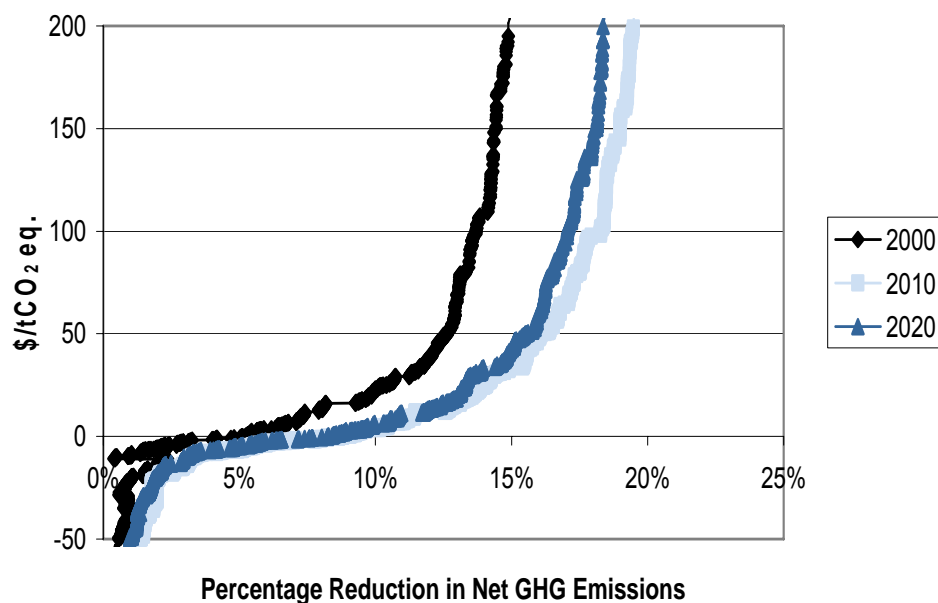
# Global Cost Curve for Livestock Management

- Smaller percentage reductions available for livestock management
- Potentially other GHG benefits not being captured; no process model analogous to DNDC/DAYCENT
- Negative cost options
  - Adoption barriers



# Aggregate Global Cost Curve for Agriculture

- Large outward shift between 2000 and 2010, primarily due to dynamic impacts on soil C for rice options
- Total global mitigation around 15% at about \$30/tCO<sub>2</sub>eq in 2010 and 2020



# Conclusions

- Agriculture contributes significantly to GHG emissions and emissions are expected to increase
- Combination of biophysical models, consistent global data sets (to the extent possible), and disaggregated crops and irrigation status in this study enables estimation of costs of numerous GHG mitigation options throughout the world
- Provides aggregate regional information to compare agriculture with other sectors
- Numerous areas for future work
  - Additional sensitivity analysis
  - More mitigation options and combinations
  - Adoption of options by region
  - Market feedback
  - Impacts of climate change on agricultural conditions, GHG emissions, and mitigation potential