Economic Potential for Agricultural Non-CO2 Greenhouse Gas Mitigation: An Investigation in the United States

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Economic Potential for Agricultural Non-CO2 Greenhouse Gas Mitigation: An Investigation in the United States- Abstract

This paper addresses the economic potential of U.S. agriculture and forestry to mitigate emissions considering carbon, nitrous oxide and methane focusing to a large extent on the possibilities for Non CO2 strategies both independently and in an overall approach. It also reports on an examination of the dynamics of non-CO2 mitigation strategies.

The paper reports results from a multi-period analysis of agricultural and forestry response to prices for GHG offset production. The model used is called FASOMGHG and is a 100 year forest and agriculture model .It covers GHG mitigation activities in 11 U.S. regions and 63 U.S. Sub-State regions), 28 foreign regions for 8 commodities, plus world market for 50+ other commodities. The 100 year period is simulated in decadal time steps. The forestry and agricultural sectors are linked through land and some commodity transfers. The model has rather detailed coverage of agricultural carbon and non-CO2 plus forest carbon management alternatives.

Using FASOMGHG marginal abatement curves are generated under alternative policy scenarios. The model results give overall and component response at varying carbon equivalent prices revealing an “optimal” portfolio of agricultural greenhouse gas emission related management alternatives. We also observe model results on commodity and factor prices, levels of production, exports and imports, management choices, resource usage, and environmental impacts.

Empirically carbon equivalent prices were varied from $0 per metric ton to $100 as constant real price for 100 years. The possible contributions of the gasses were treated both collectively and independently. In particular scenarios where run where only one of CO2, CH4 and N2O were eligible for payments followed by scenarios when non CO2 gasses were all that were eligible and then where all gasses were eligible.

A number of potential insights arise from the model analysis

•Non CO2 gasses can be a significant player although they are somewhat less than one half as important as sequestration

•NonCO2 gasses actions are persistent growing over time while sequestration saturates and diminishes

•Competition exists between strategies and independent assessments can be misleading

•Independent nonCO2 strategies cause significant leakage in the CO2 category

•Enteric fermentation and fertilization based N2O management are highly complementary with CO2 management

More can be found on this type of analysis in the carbon related writings of McCarl and others that can be found on agecon.tamu.edu/faculty/mccarl.

PROJECT/ PAPER OBJECTIVES

- Assesses the economic potential of U.S. agriculture and forestry to mitigate emissions considering carbon, nitrous oxide and methane
- Focus on the role of Non CO2 strategies both independently and in an overall approach
- Examine the dynamics of non-CO2 mitigation strategies

ROLES OF U.S. AG & FORESTRY

- A carbon or GHG sequestering sink
- Offsetting net GHG emissions
- Operating in a mitigating world
- EMISSION REDUCERS

Globally

  - Ag and forestry emit 70% of N2O
  - Ag and forestry emit 50% of CH4
  - Ag and forestry emit 5% or 20% (including tropical deforestation) of CO2

ROLES OF US AG & FORESTRY in CH4

Emission accounting

- Manure emissions

Mitigation Strategies

- Less rice acreage
- Fewer animals
- Liquid manure management
- Change feeding

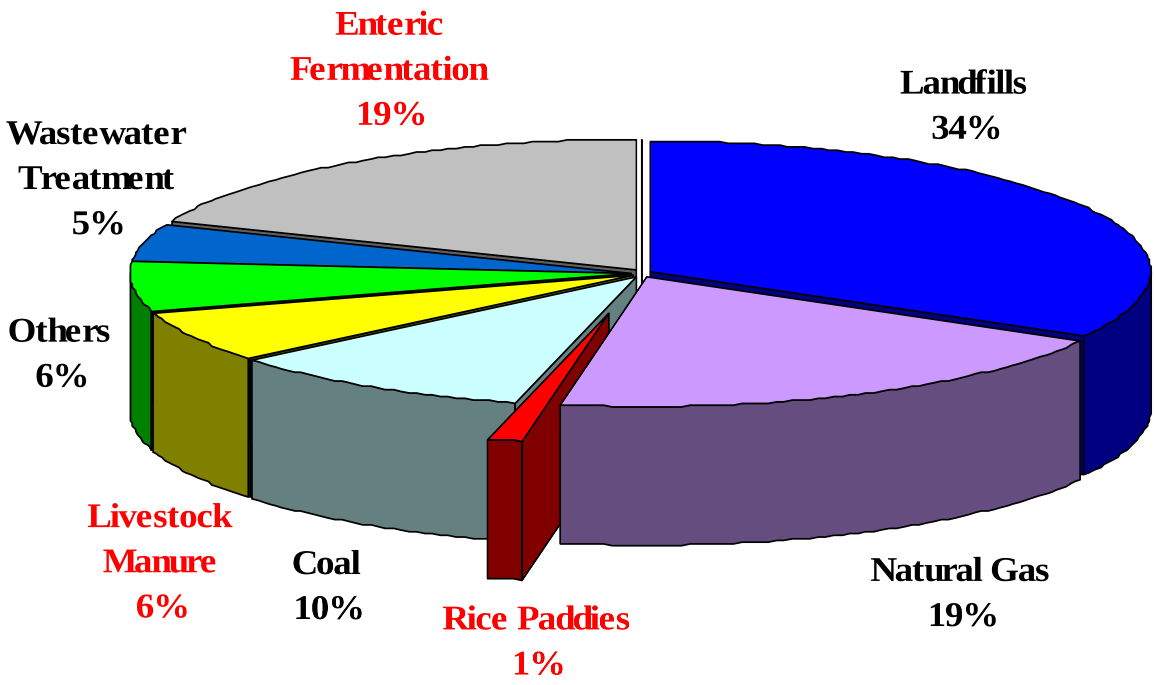


Figure 1: U.S. Source of CH4 Emissions in Tg CO2 Eq.

Source: EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks:1990-2001 Table ES-10, page ES 16, April 15, 2003.

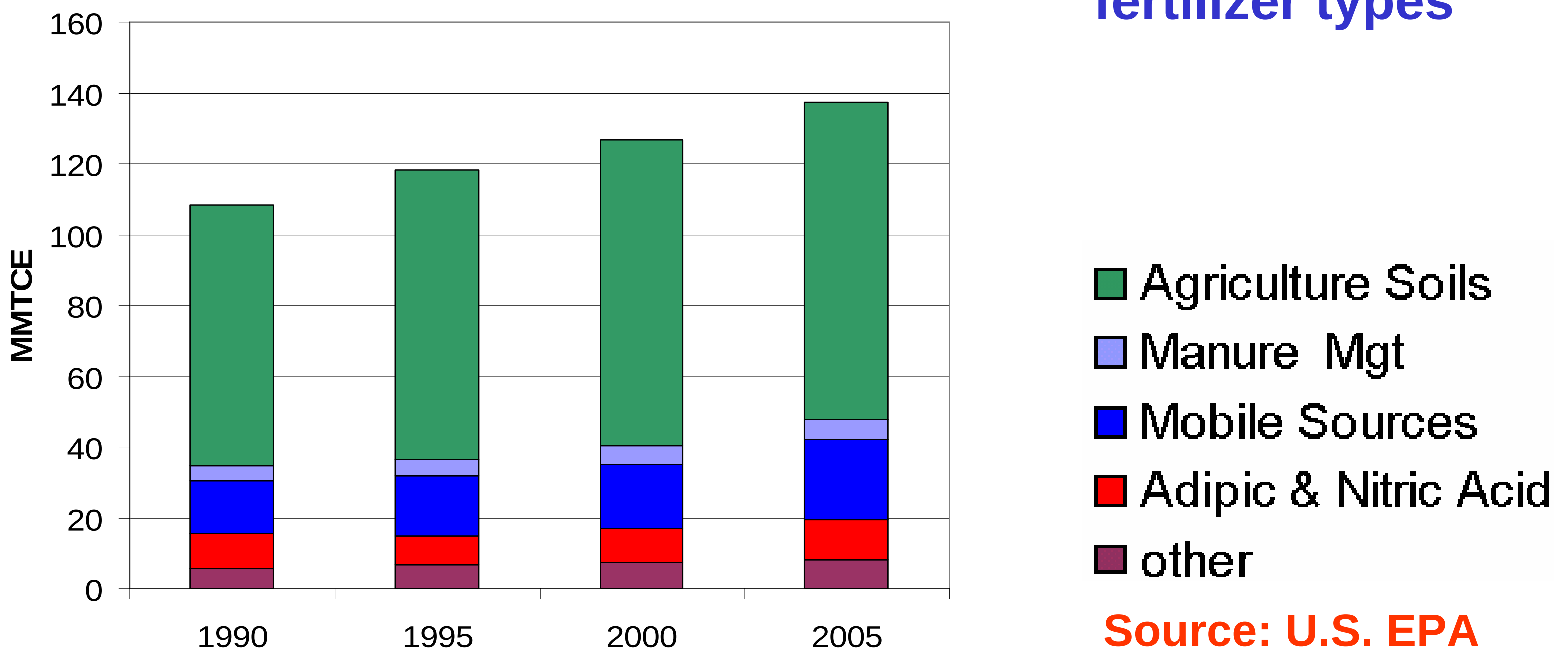
ROLES OF U.S. AG & FORESTRY: N2O

Emission accounting

- De-nitrification
- Air volatilization
- Livestock manure emissions

Mitigation Strategies

- Change of crop mix
- Less Nitrogen fertilization
- Choice between N-fertilizer types



Source: U.S. EPA

Figure 1: The U.S. Nitrous Oxide Emissions 1990-2020

BASIC ASSESSMENT

- Multi-period analysis of ag/forest response
- Marginal abatement curve giving overall and component response at varying carbon equivalent prices
- Also wish to observe commodity and factor prices, levels of production, exports and imports, management choices, resource usage, and environmental impacts

MODELING APPROACH

- 100 year forest and agriculture model - FASOMGHG
- Covers GHG mitigation activities in U.S. regions (across 11 regions and 63 U.S. Sub-State regions), 28 foreign regions for 8 commodities, plus world market for other commodities.
- Simulates 100 years in decade time steps.
- Depicts sector linkage mainly through land transfers.

MODELING APPROACH

- When run with a price solution reveals a "optimal" portfolio of agricultural greenhouse gas emission related management alternatives.
- Rather detailed coverage of agricultural carbon and non-CO2 plus forest carbon management alternatives.

FASOMGHG REGIONS

GHG ACTIVITIES IN FASOMGHG

- Multiple GHG mitigation strategy setup
- Detailed GHG emission accounting
  - Forest carbon
  - Soil carbon
  - N_2O
  - CH_4
  - Fuel use carbon emissions
- National GHG balance
- GWP weighted sum of all GHG accounts
- GHG Policy implementation

NON-CO2 SOURCES IN FASOMGHG

N2O

- Commercial Fertilizer
- Livestock Manure
- Sewage Sludge
- Fixing Crops
- Crop Residues
- Histosol
- Pasture/range/paddock livestock
- Volatilization
- Leaching and Runoff

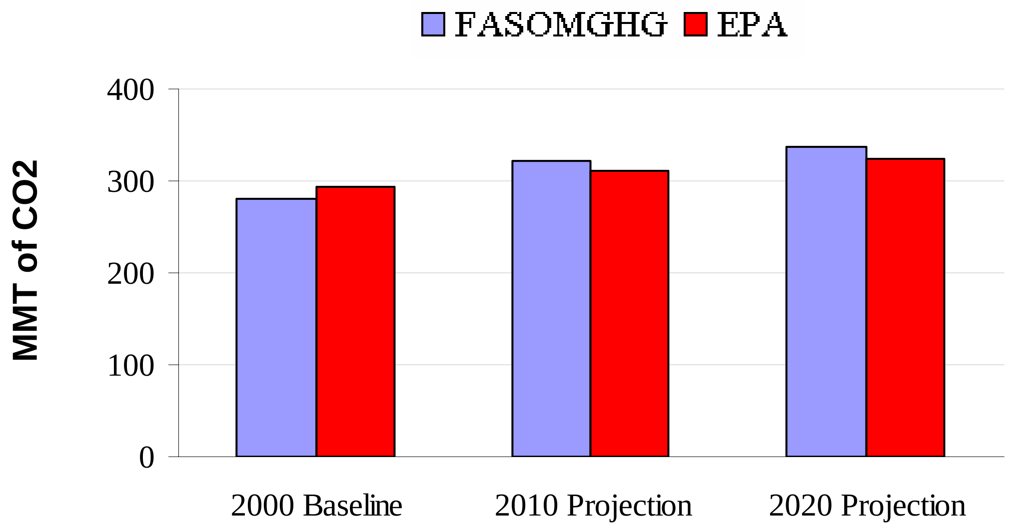
CH4

- Enteric Fermentation
- Manure Management Systems
- Rice Cultivation
- Agricultural Residue Burning

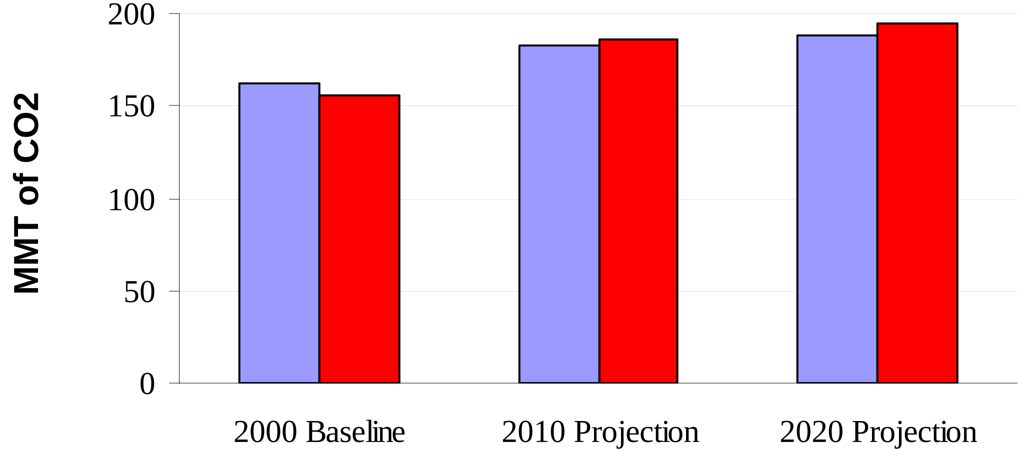
FASOMGHG MITIGATION OPTIONS

Strategy	Basic Nature	CO2	CH4	N2O
Crop Mix Alteration	Emis, Seq	X		X
Crop Fertilization Alteration	Emis, Seq	X		X
Crop Input Alteration	Emission	X		X
Crop Tillage Alteration	Emission	X		X
Grassland Conversion	Sequestration	X		
Irrigated /Dry land Mix	Emission	X		X
Biofuel Production	Offset	X	X	X
Afforestation	Sequestration	X		
Existing timberland Management	Sequestration	X		
Deforestation	Emission	X		
Stocker/Feedlot mix	Emission		X	
Enteric fermentation	Emission		X	
Livestock Herd Size	Emission		X	X
Livestock System Change	Emission		X	X
Manure Management	Emission		X	X
Rice Acreage	Emission	X	X	X

CALIBRATION



(a) N2O



(b) CH4

MODEL ANALYSIS

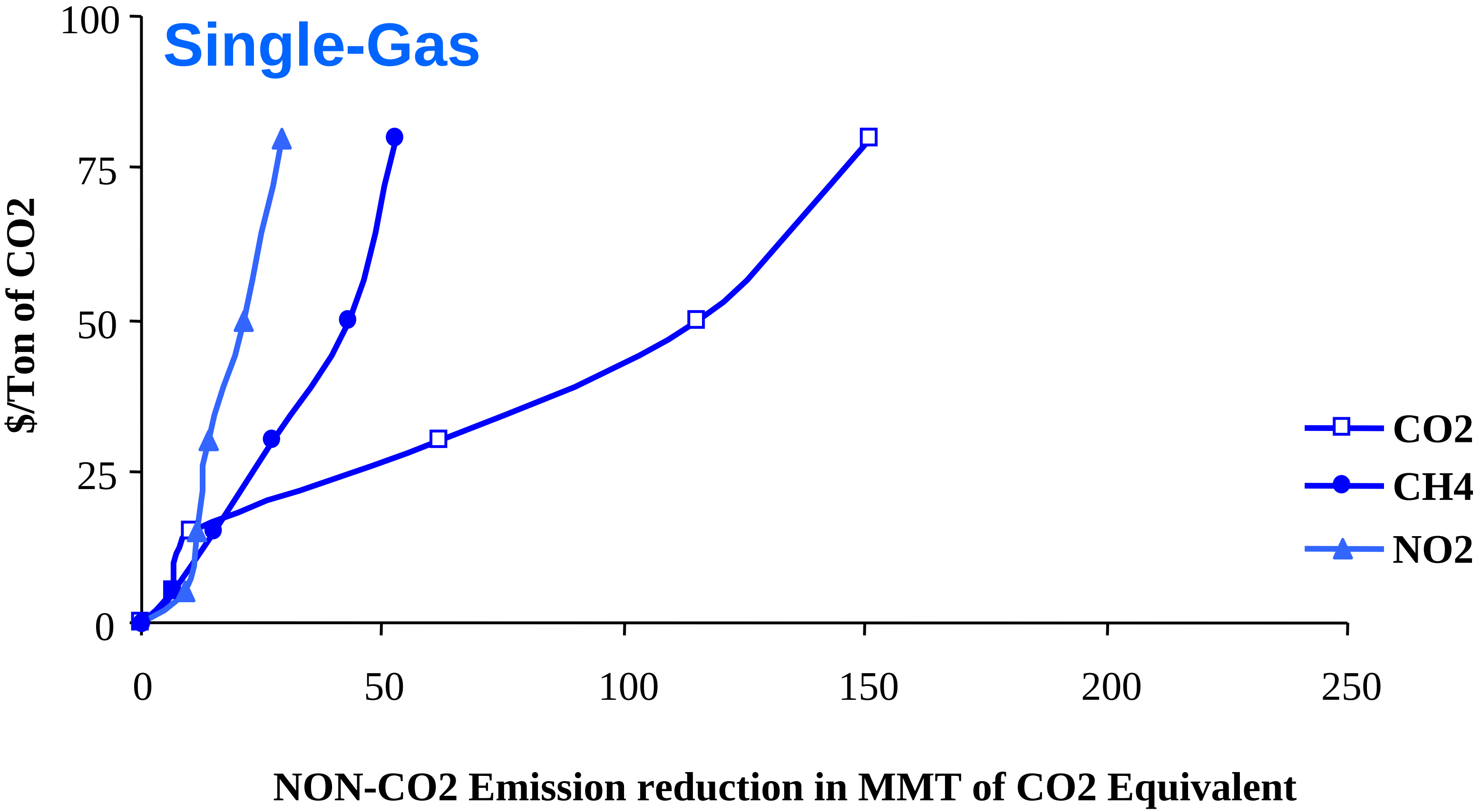
Experiments

- Prices varied from $0 per ton to $100 as constant real price for 100 years
- Gasses treated collectively or independently
    - CO_2 only – single gas
    - CH_4 only – single gas
    - N_2O only – single gas
    - CH_4 and N_2O – Non CO_2 gasses
    - All gasses – CH_4+CO_2+N_2O

Observed items

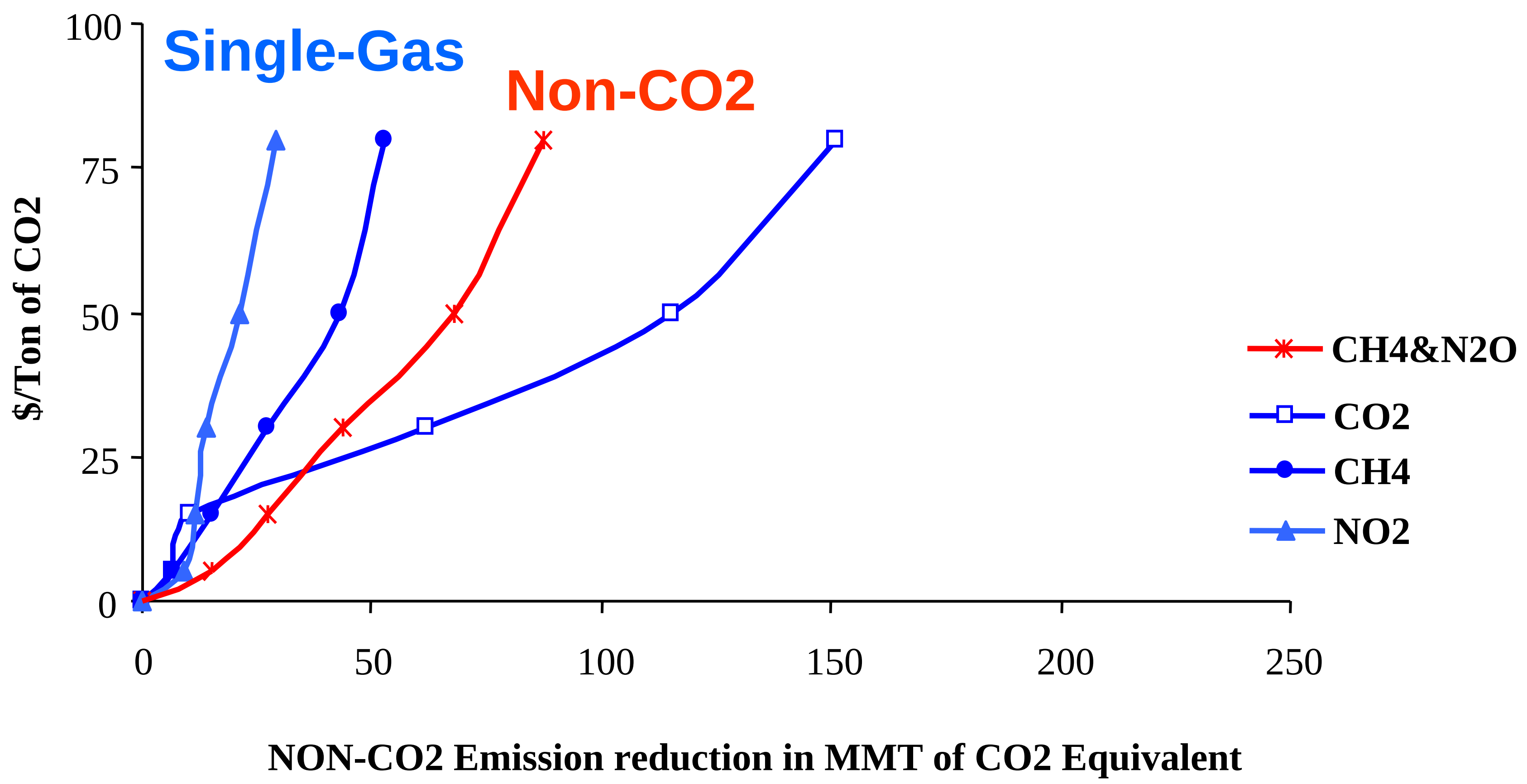
- Amount of major strategies used
- Prices, welfare

ECONOMIC POTENTIAL



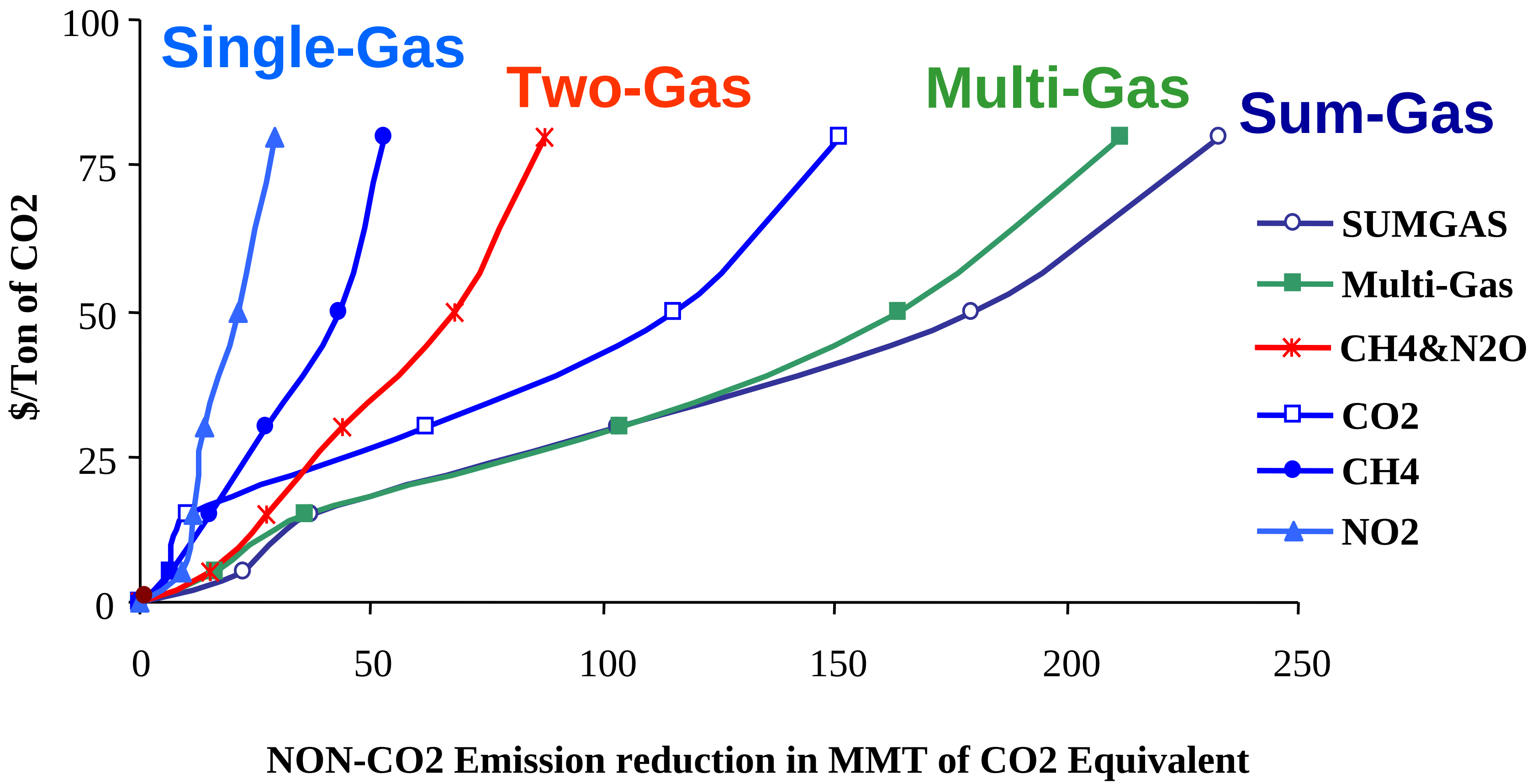
Economic potential: **how much one would get if this was the only gas paid for.**

ECONOMIC POTENTIAL



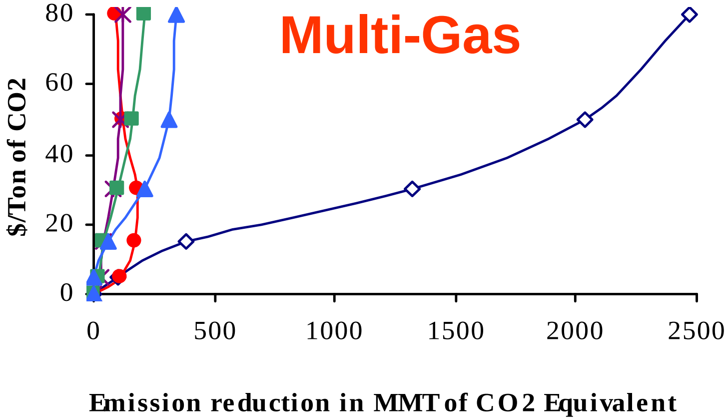
Economic potential: **how much one would get if this was the only strategy employed or id only non-co2 was paid.**

COMPETITIVE vs. ECONOMIC POTENTIAL

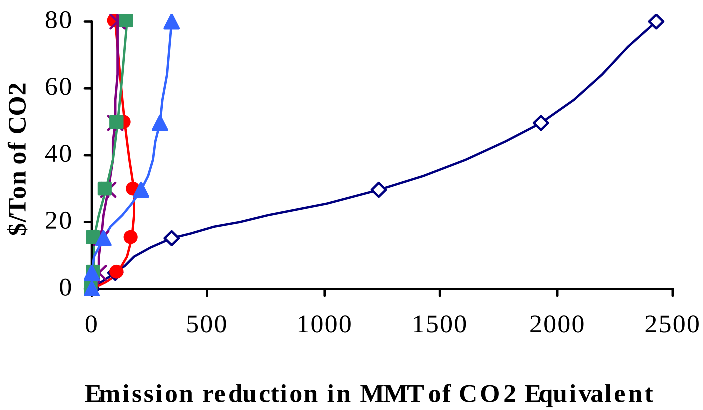


Results do not add up die to competition and complementarity

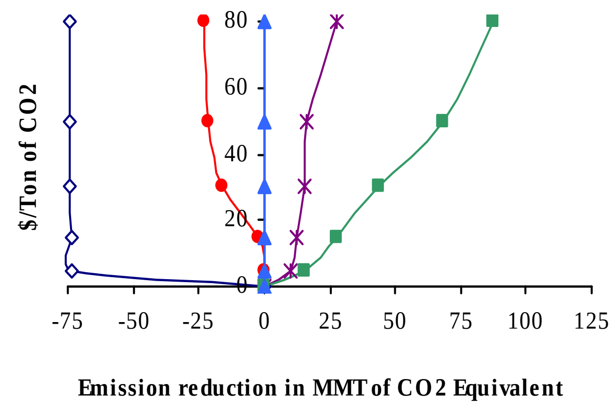
Portfolio Composition



Single-Gas (CO2)



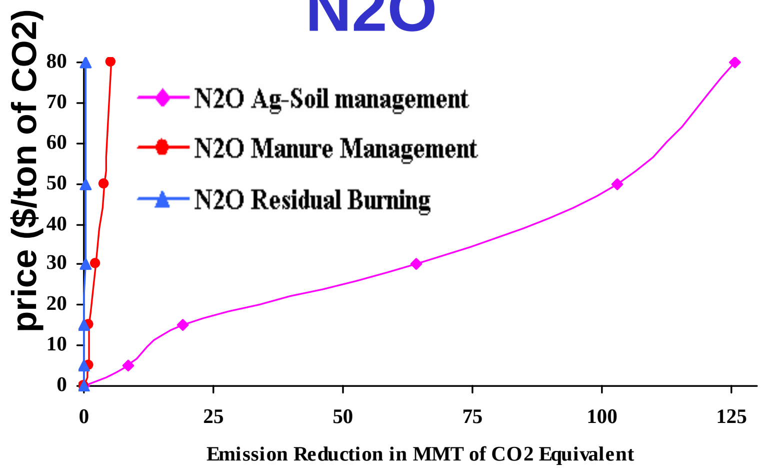
Two-Gas



All forest the big one
Paying for CO2 only about same as including NonCO2
Paying for non CO2 only can do strange things to CO2

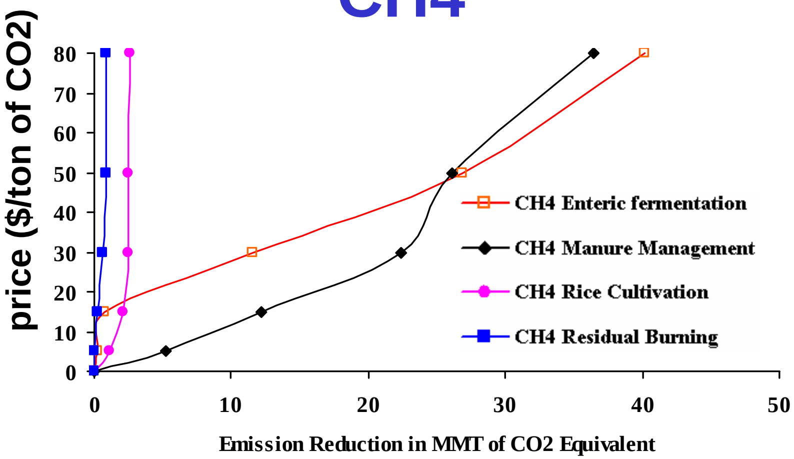
Portfolio Shares

N2O

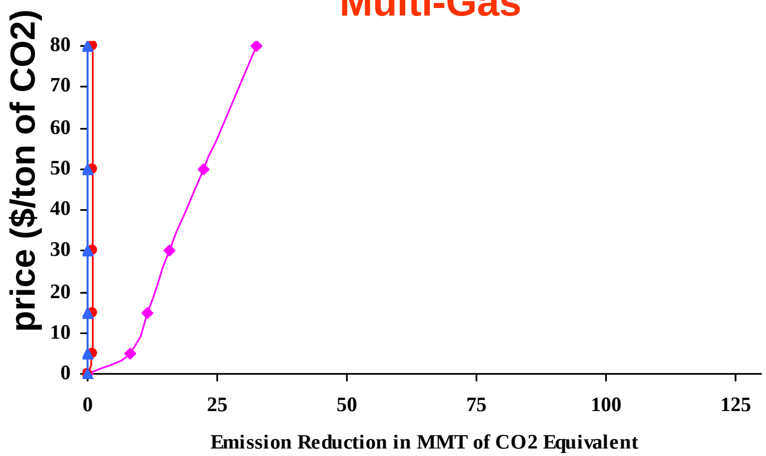


Multi-Gas

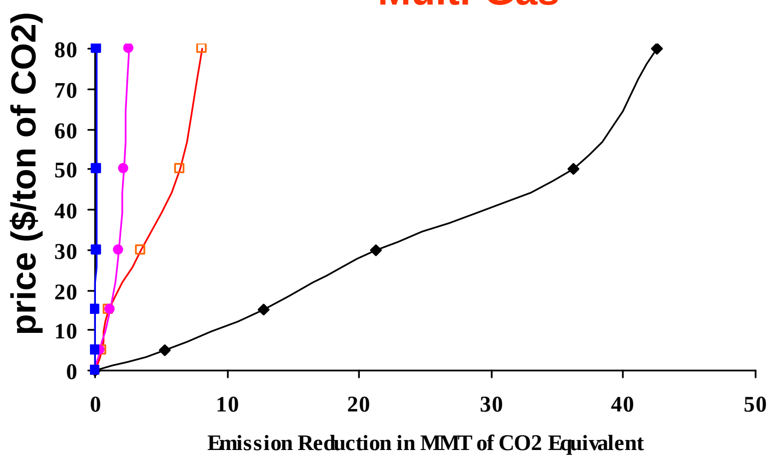
CH4



Multi-Gas



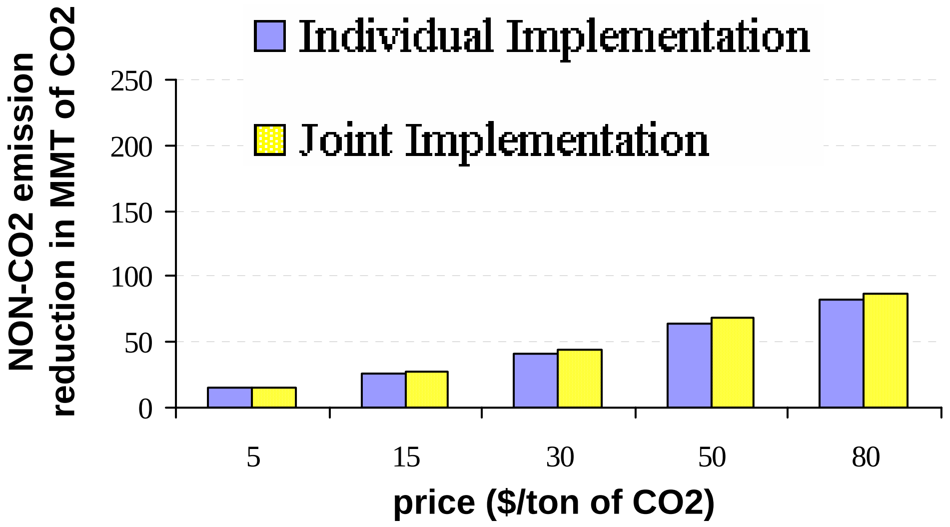
Two-Gas



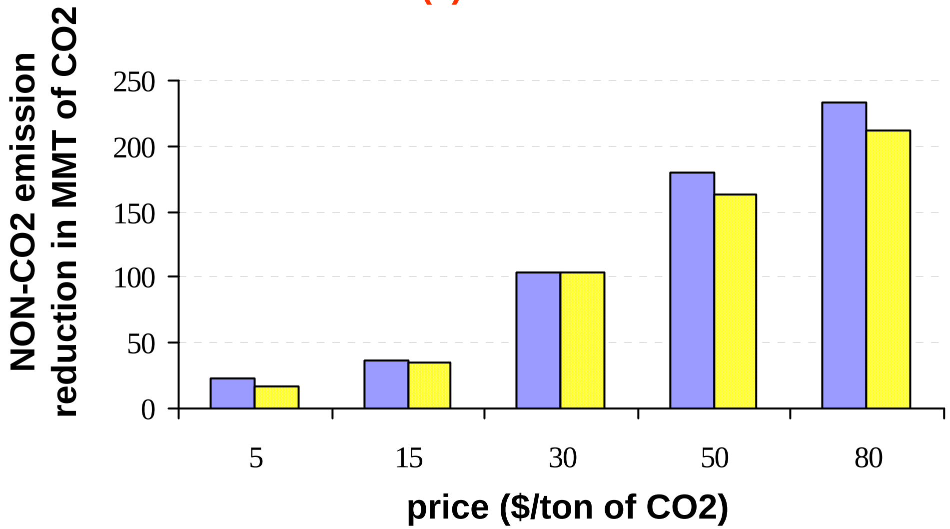
Two-Gas

Enteric and fertilizer very complementary with CO_2
Manure unaffected by multi gas

INDIVIDUAL vs. MULTIGAS IMPLEMENTATION



(a) N20 and CH4

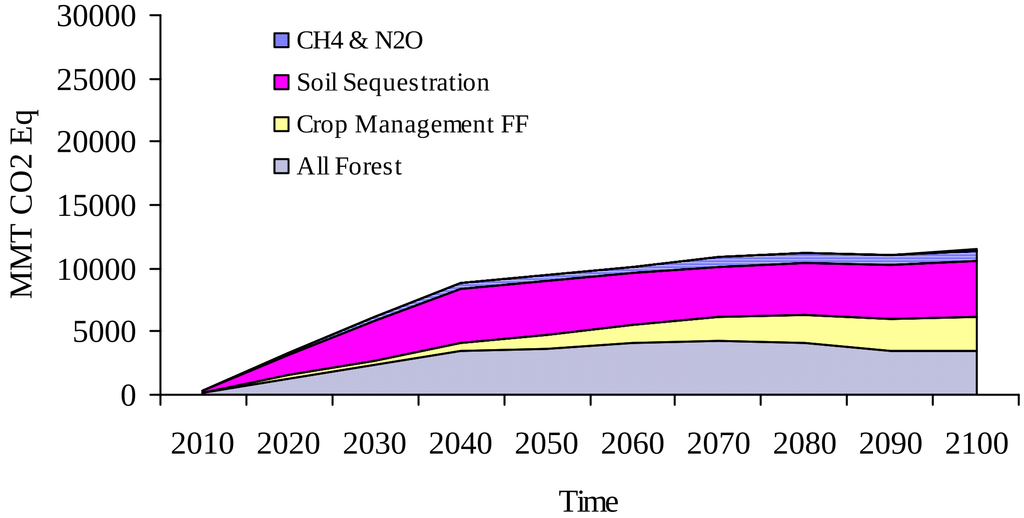


(b) AllGas

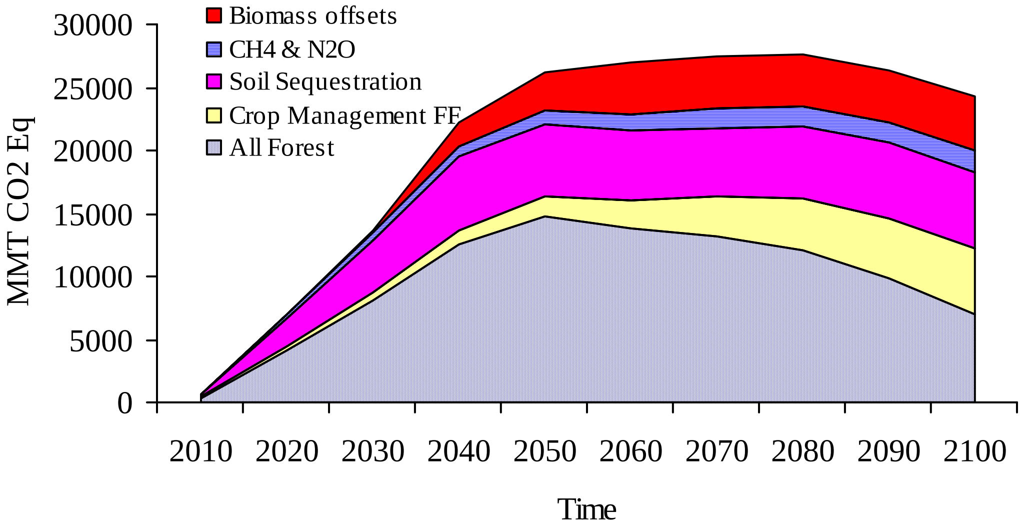
- **Joint implementation achieves more quantity reduction at the same price => interaction effects**
- **Individual implementation overstates reduction => land competition**

DYNAMICS OF GHG MITIGATION

Multi-Gas



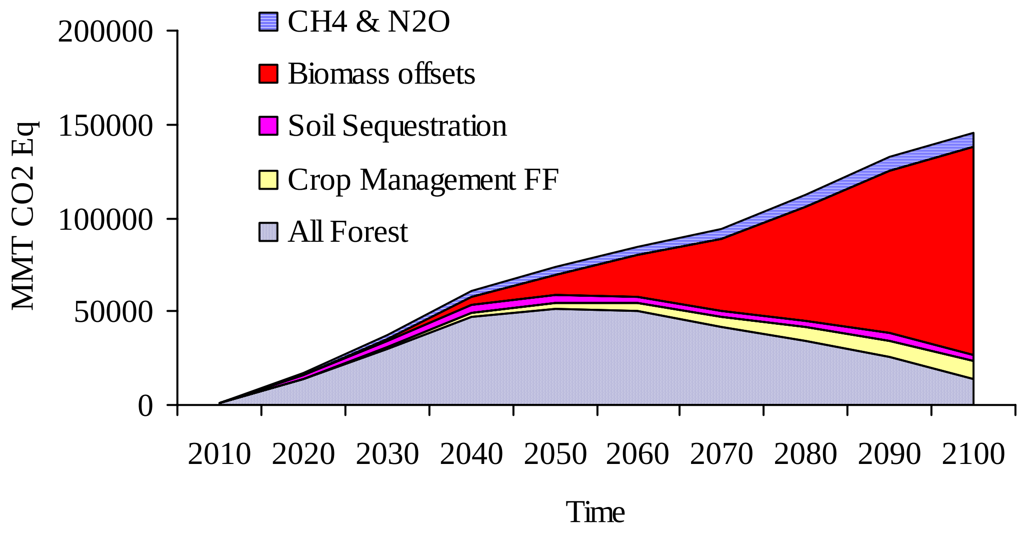
(a) at $5/ton of CO2



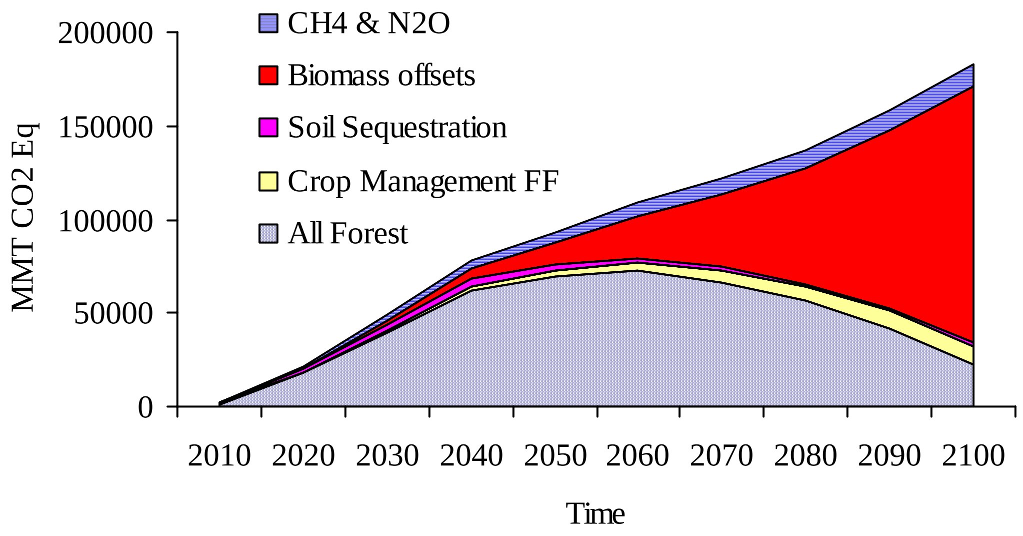
(b) at $15/ton of CO2

DYNAMIC OF GHG MITIGATION

Multi-Gas



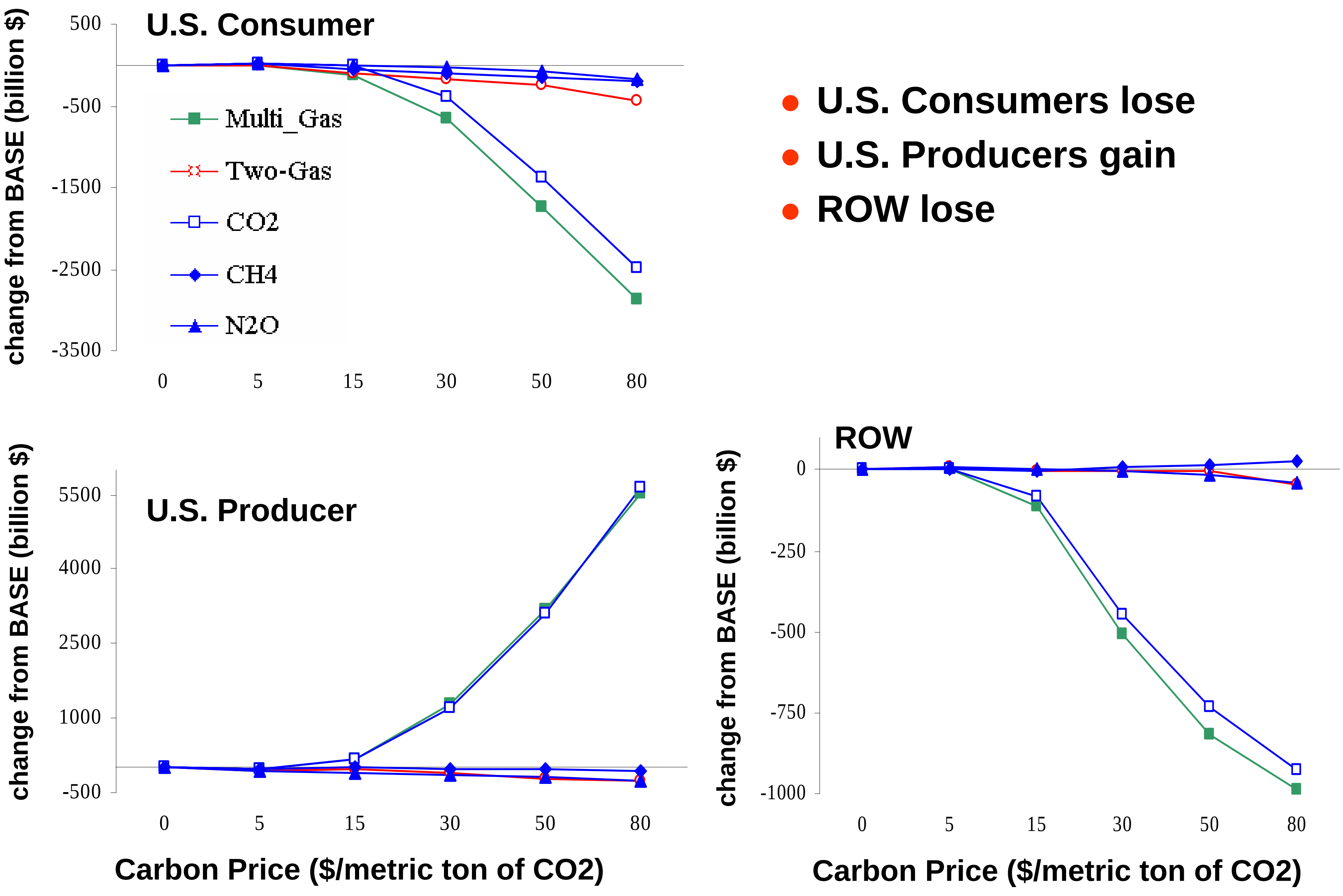
(c) at $50/ton of CO2



(d) at $80/ton of CO2

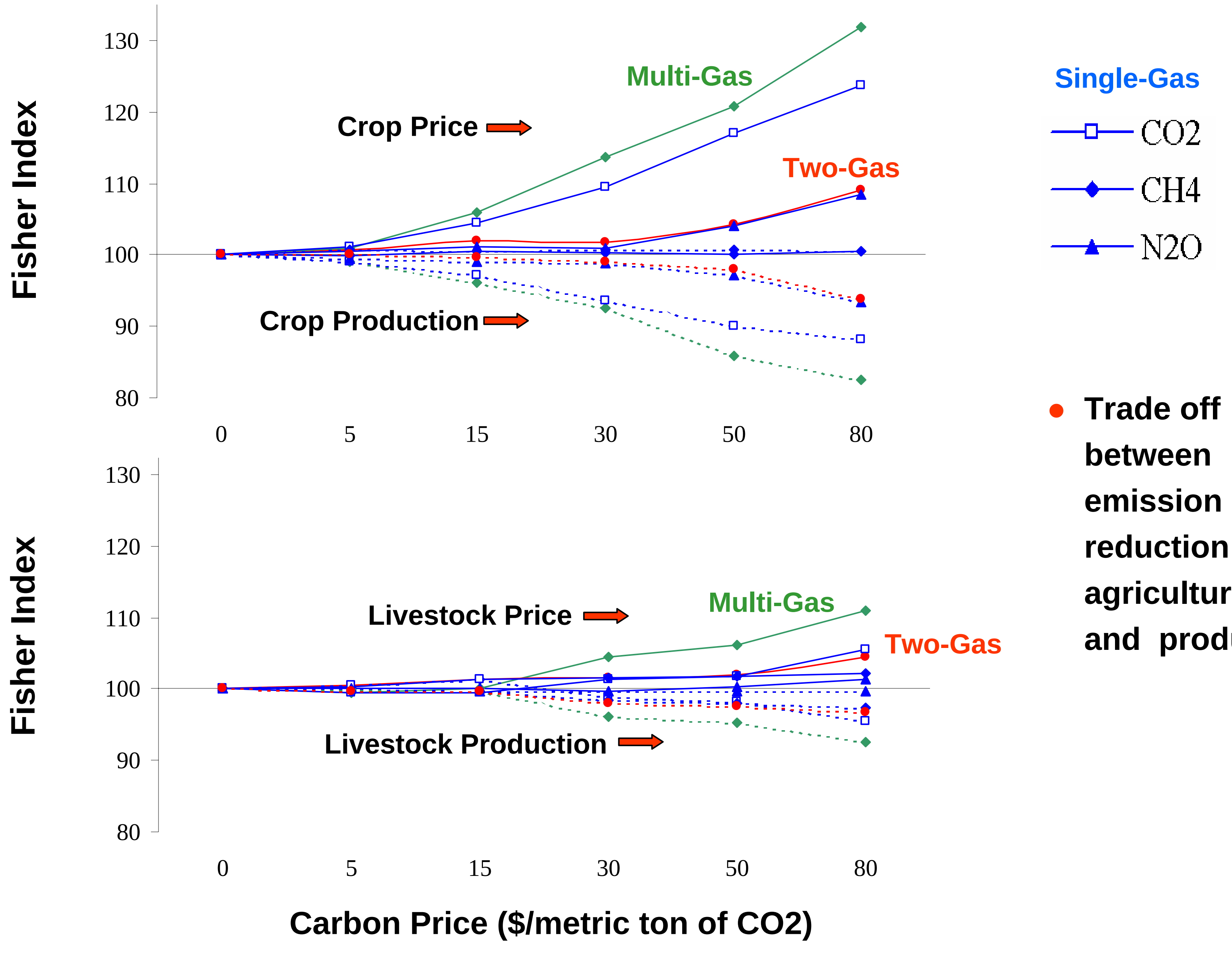
Sequestration saturates
Biofuels and non CO2 grow in long run
Biofuel dominates at high price

WELFARE IMPACT



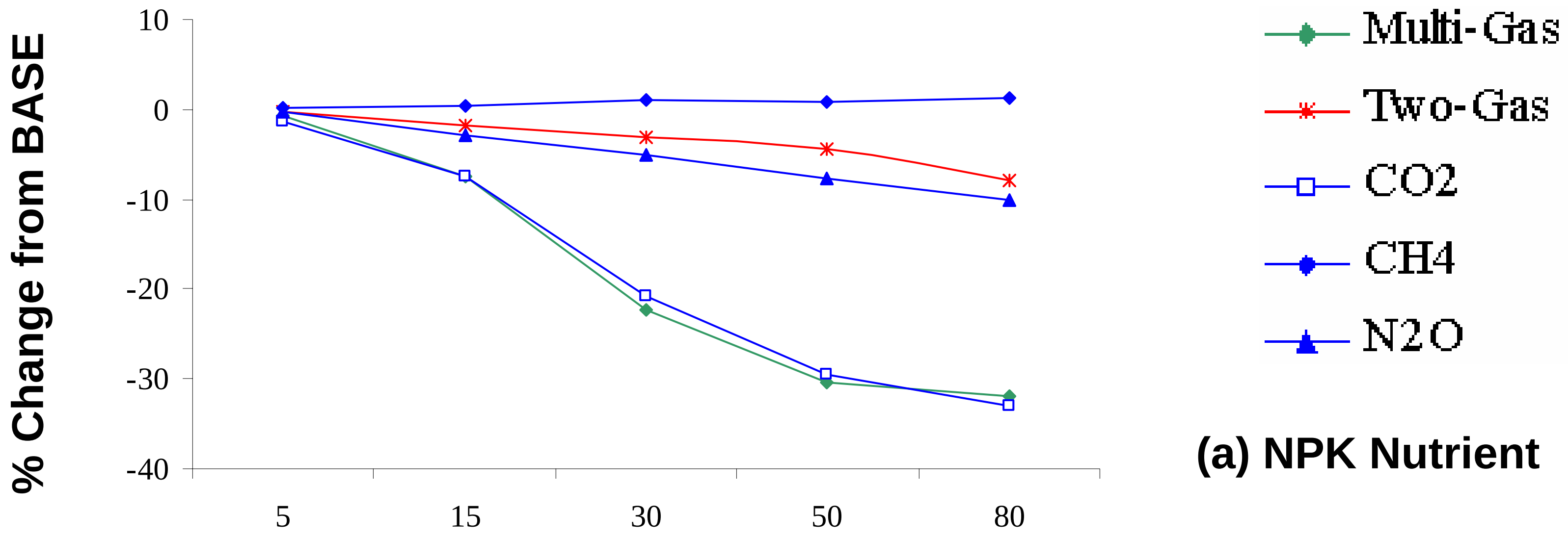
- **U.S. Consumers lose**
- **U.S. Producers gain**
- **ROW lose**

ECONOMIC INDICATORS

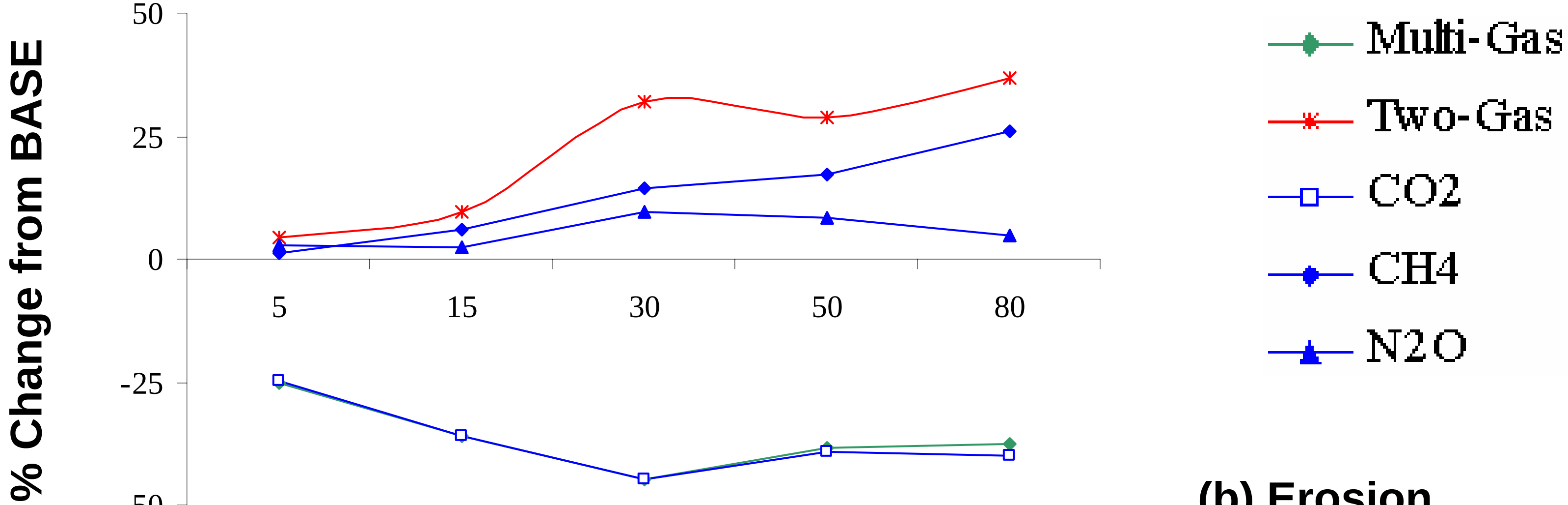


- **Trade off between emission reduction and agricultural price and production**

ENVIRONMENTAL IMPACTS



(a) NPK Nutrient



(b) Erosion

Carbon Price ($/metric ton of CO2)

FUTURE DIRECTION AND CHALLENGES

Better Livestock Enteric and fertilizer

New forestry data

Transactions cost and discounts

Appendix : CALIBRATION

Table 1. Comparison NONCO$_2$ emissions from agriculture using FASOMGHG to EPA estimation in MMT of CO$_2$

	2000 Baseline			2010 Projection			2020 Projection		
	EPA	FASOM	% Deviate	EPA	FASOM	% Deviate	EPA	FASOM	% Deviate
N_2O:									
Agricultural Soil Management:									
Managed soils	177.3	153.7	-13.3	189.7	182.0	-4.1	199.1	197.0	-1.0
Pasture, Range, and Paddock livestock	41.0	36.3	-11.4	41.0	39.1	-4.5	41.0	39.4	-3.9
Indirect Emissions	79.8	73.1	-8.4	82.6	76.6	-7.2	85.4	75.4	-11.7
Manure Management	17.2	19.8	15.4	19.9	24.5	23.5	21.9	27.7	26.5
Agricultural Residue Burning	0.7	0.5	-21.5	0.7	0.7	4.3	0.7	0.8	16.9
Total N_2O	316.0	283.4	-10.3	333.9	322.9	-3.3	348.1	340.3	-2.2
CH_4:									
Enteric Fermentation	114.5	121.6	6.0	136.4	126.5	-7.3	139.4	128.0	-8.1
Manure Management Systems	38.9	30.0	-22.0	41.6	48.7	17.0	46.4	51.9	11.9
Rice Cultivation	7.5	9.4	25.8	7.5	6.0	-19.4	7.5	6.4	-14.5
Agricultural Residue Burning	0.9	1.0	22.0	0.9	1.4	68.9	0.9	1.6	86.6
Total CH_4	161.8	162.1	-0.1	186.4	182.7	-2.0	194.1	188.0	-3.2
Total non-CO_2	477.8	445.5	-6.7	520.3	505.6	-2.8	542.2	528.3	-2.6

Source: U.S. Greenhouse Gas Emissions and Sinks: 1990-2001, EPA; Personal communication with a personnel at EPA.

Appendix : CALIBRATION

Table 2: Comparison N2O and CH4 emissions from manure management using FASOMGHG to EPA estimation in MMT of CO_2

	2000 Baseline		2010 Projection		2020 Projection	
	EPA	FASOM	EPA	FASOM	EPA	FASOM
N_2O Emissions:						
Beef	5.4	6.7	6.8	9.6	7.6	10.3
Dairy	3.9	5.5	3.8	5.0	3.4	4.8
Horses	0.2	0.2	0.2	0.5	0.2	0.5
Poultry	7.2	7.0	8.7	9.1	10.3	11.7
Sheep	0.1	0.0	0.0	0.0	0.0	0.0
Swine	0.4	0.3	0.4	0.4	0.4	0.4
Total N_2O	**17.2**	**19.8**	**19.8**	**24.5**	**21.9**	**27.7**
CH_4 Emissions:						
Beef	3.4	1.5	3.8	2.1	3.8	2.4
Dairy	11.8	10.1	15.8	16.0	18.6	18.3
Horses	0.7	0.7	0.6	1.3	0.7	1.3
Poultry	2.6	3.0	3.1	4.7	3.6	5.9
Sheep	0.1	0.1	0.0	0.0	0.0	0.0
Swine	14.1	14.8	18.3	24.6	19.7	24.0
Total CH_4	**32.7**	**30.0**	**41.5**	**48.7**	**46.4**	**51.9**
Total	49.8	49.9	61.4	73.2	68.2	79.6

Source: U.S. Greenhouse Gas Emissions and Sinks: 1990-2001, EPA; Personal communication with a personnel at EPA.

Appendix : CALIBRATION

Table 3: Comparison CH4 emissions from enteric fermentation using FASOMGHG to EPA estimation in million metric tons of CO_2 equivalent

	2000		2010		2020	
	EPA	FASOM	EPA	FASOM	EPA	FASOM
CH_4:						
Beef	91.7	91.5	101.7	96.1	102.3	95.9
Dairy	26.9	24.7	29.7	25.7	31.8	27.3
Horses	2.0	2.3	2.1	2.1	2.1	2.1
Sheep	1.2	1.2	0.8	0.8	0.7	0.7
Swine	1.9	1.9	1.9	1.9	2.1	2.1
Total CH_4	123.7	121.6	136.2	126.5	139.0	128.0

Source: U.S. Greenhouse Gas Emissions and Sinks: 1990-2001, EPA;
Personal communication with a personnel at EPA.