Effects of GHG Mitigation Policies on Global Agriculture: a CGE approach

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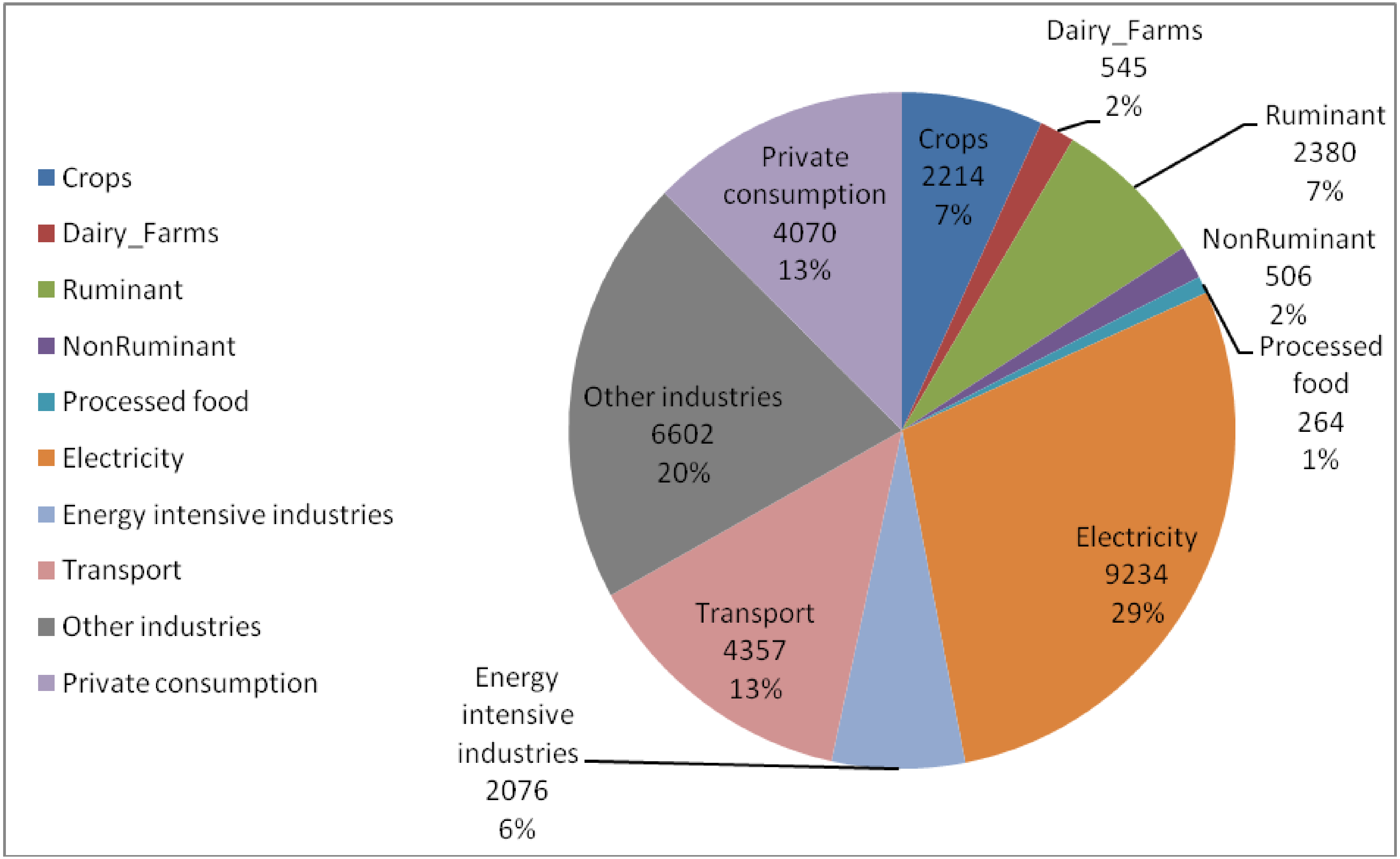
To the OECD Expert Meeting on Climate Change, Agriculture and Land Use Modelling

9 February, 2011, Paris

Motivation

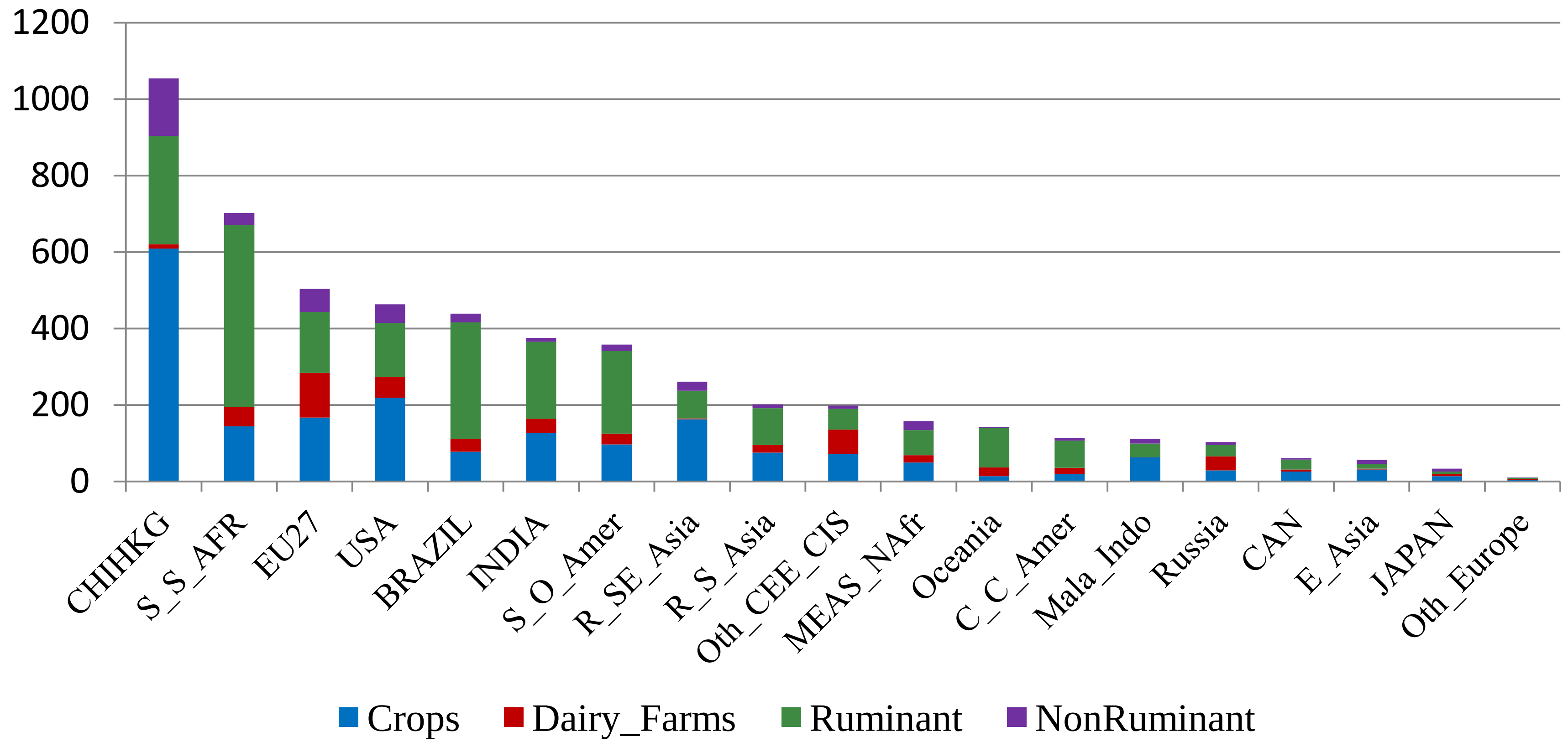
- **Limited analysis of land-based mitigation policies to-date**
- **We seek to contribute to this literature, shedding light on the following questions:**
  - **What is the relative contribution of agriculture and forestry to global GHG abatement?**
  - **How do global mitigation policies affect the pattern of agricultural production, consumption and trade?**
  - **What are the interactions between REDD (+afforestation) and agricultural activities?**
  - **What about leakage effects when developing countries do not participate in global climate policy?**
  - **What are the nutritional impacts of devoting additional land to GHG mitigation?**

Global GHG emissions (MtCO2-eq) ignoring land use change emissions



Constructed from 2001 CO2 and non-CO2 GTAP data

Ruminant sector & developing regions produce majority of agricultural non-CO_2 GHG emissions ($MtCO_2eq$)



Methodology: Overview

- Global general equilibrium GTAP-AEZ-GHG model
- 31 sector and 19 region aggregation of GTAP v.6 data base
- Heterogeneous land
  - 18 Agro-Ecological Zones
- Incorporates both non-CO_2 and CO_2 emissions
  - non-CO_2 compiled in GTAP format for all sectors (Rose and Lee, 2009)
  - CO_2 emissions from fossil fuel combustion in all sectors (Lee, 2007)
  - Permits analysis of trade-offs between emission reduction in land using sectors and industrial activities
- Fossil fuels abatement through energy substitution, reduction in size of energy intensive sectors
- Non-CO_2 mitigation in agriculture and forest carbon sequestration calibrated to partial equilibrium studies

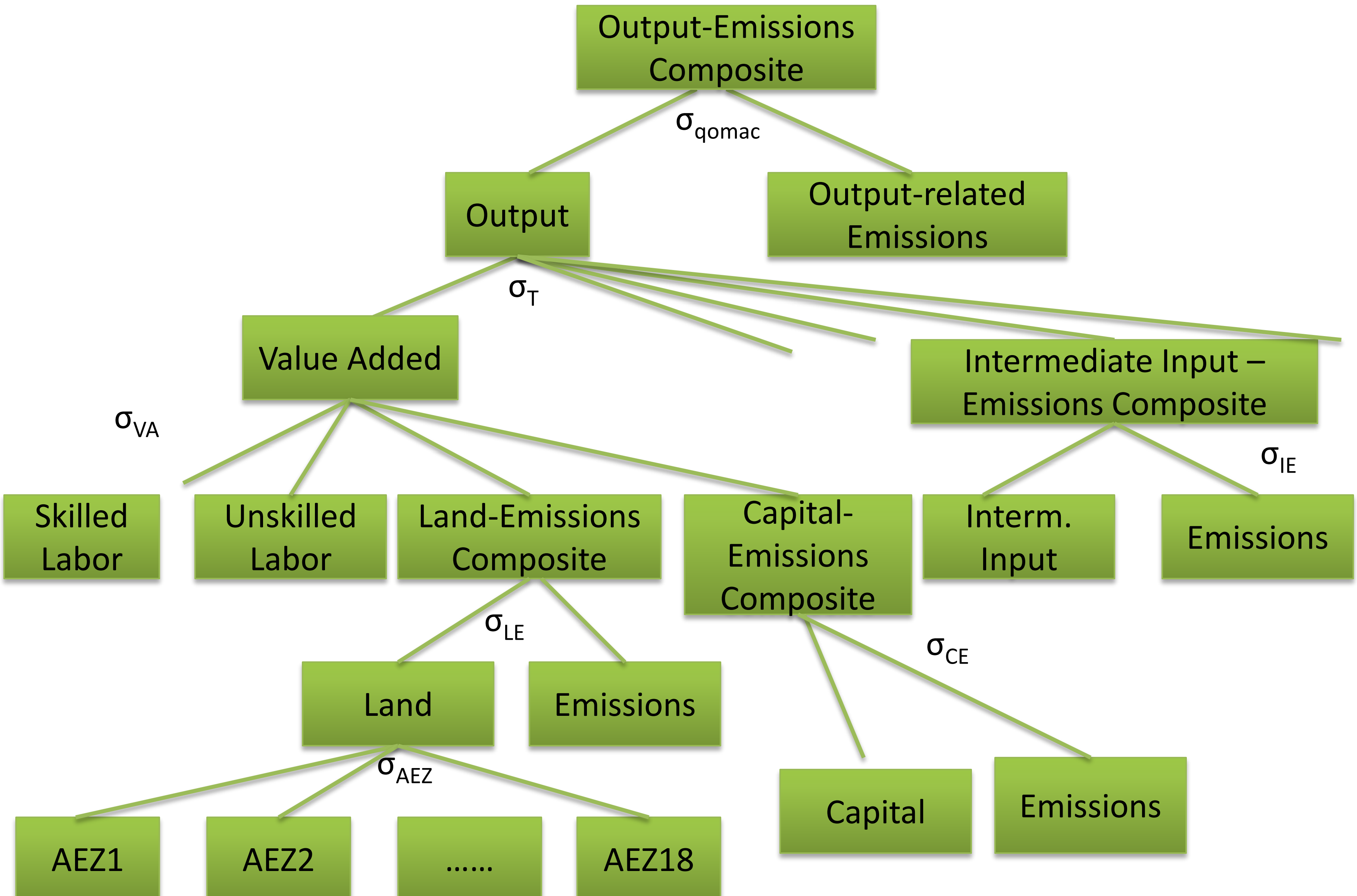
Heterogeneous land

- **18 Agro-Ecological Zones**
  - **6 growing periods (6 categories x 60 day intervals)**
  - **3 climatic zones (tropical, temperate and boreal)**
- **The competition for land within a given AEZ across uses is constrained to include activities that have been observed to take place in that AEZ**
- **AEZs are inputs into a single national production function for each commodity**
- **Within AEZ, land supply across alternative uses is constrained via a nested CET frontier**
  - **First, allocation of land among three land cover types, i.e. forest, pasture, cropland**
  - **Then decision on the allocation of land between various crops (likewise) between dairy and ruminants**

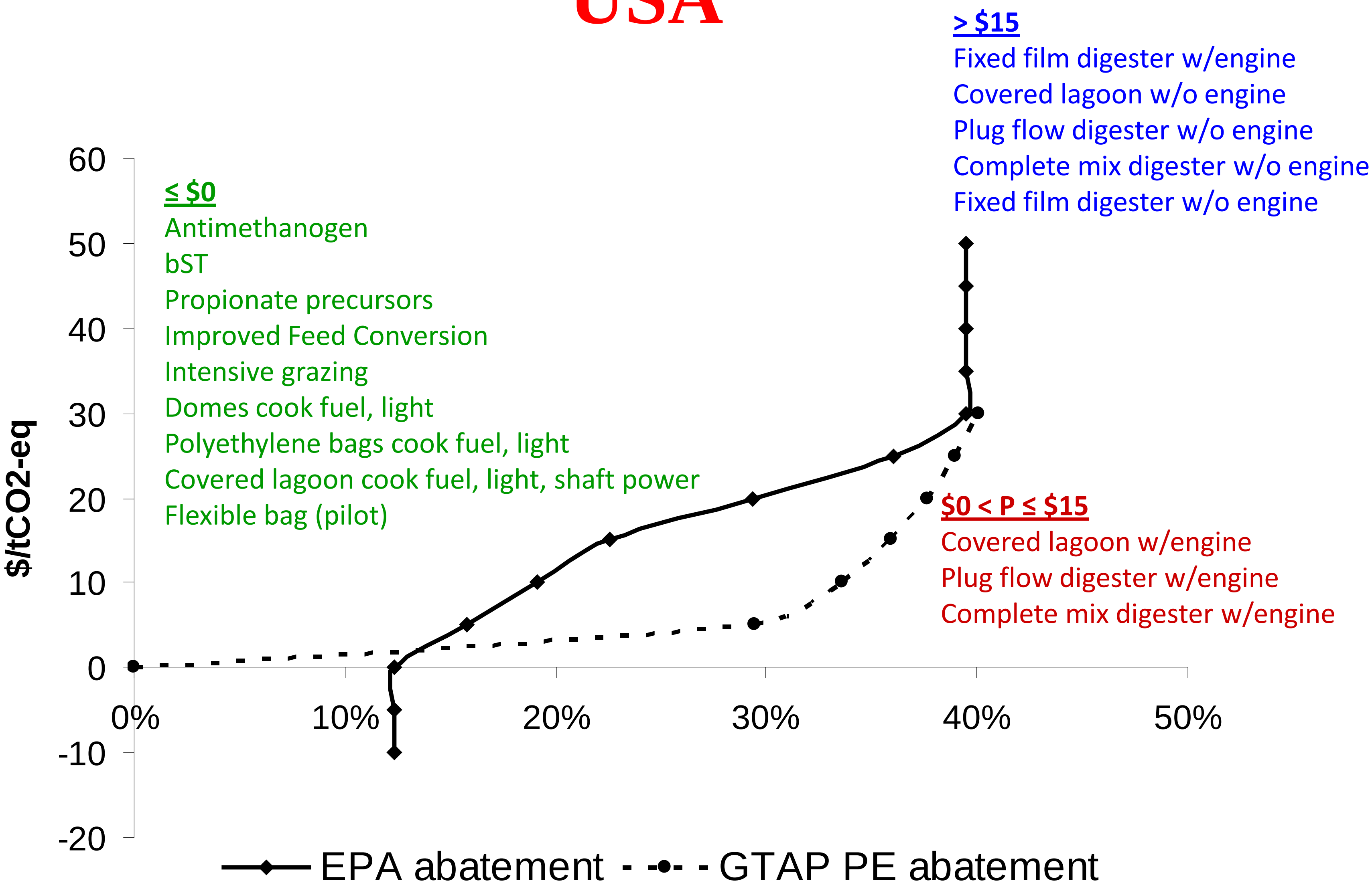
What scope for *mitigation responses* in agriculture?

- USEPA engineering-type mitigation cost estimates for key non-CO_2 emissions sources
- Three types of agricultural production mitigation responses
  - Associated with intermediate input use:
    - nitrous oxide emissions from fertilizer use in crops
  - Associated with primary factors:
    - methane emissions from paddy rice land
  - Associated with sector outputs:
    - emissions from agricultural residue burning
- Additional layer of parameters to allow for substitution between emissions and specific inputs
  - Changing emission intensity of inputs or of output
  - Preserving production structure while calibrating mitigation response

Agricultural sectors production structure



PE calibration illustrated– Dairy farms USA



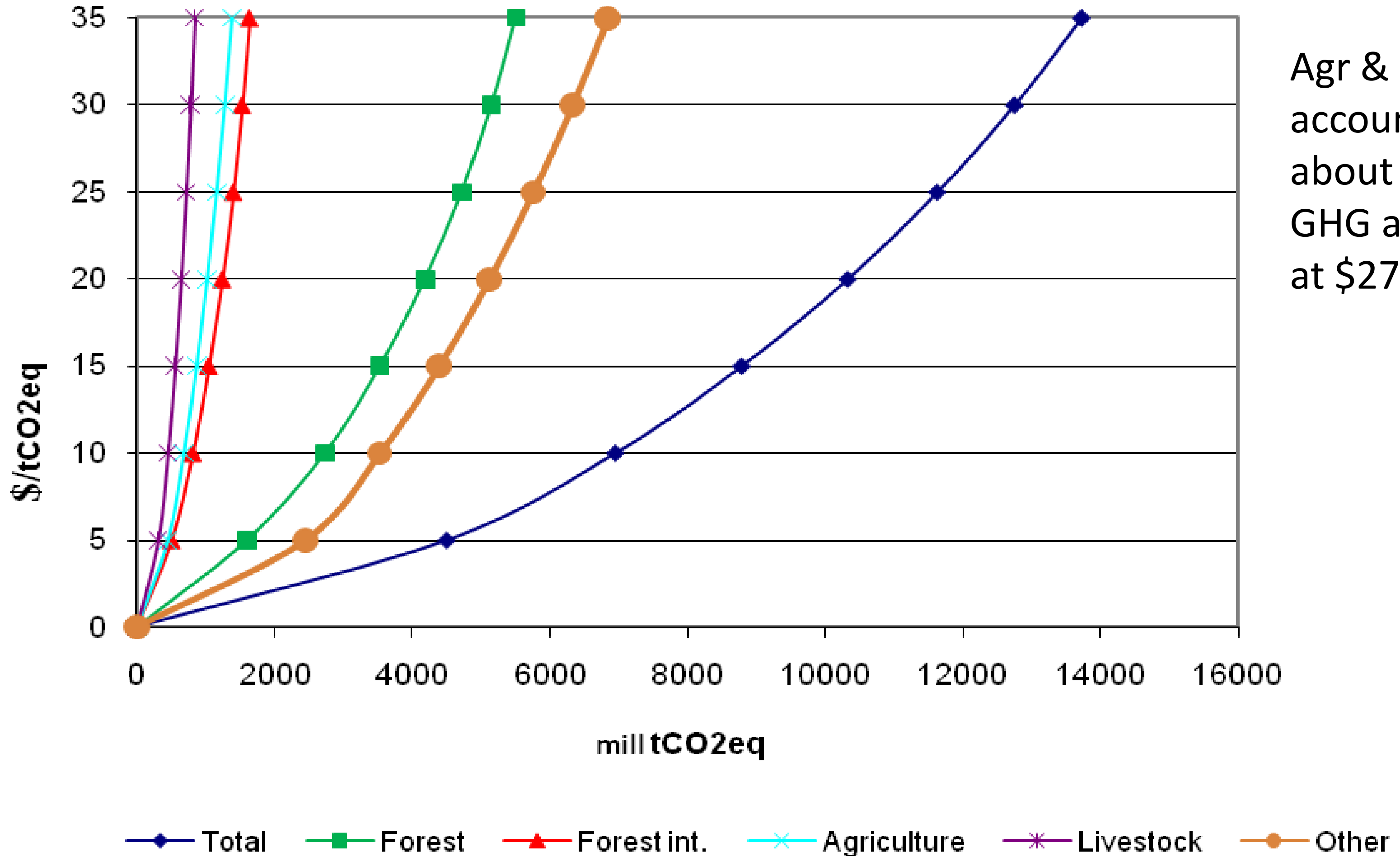
Forest carbon supply curves

- **Modified Global Timber Model (GTM) of Sohngen and Mendelsohn (2007)**
  - **Dynamic forward looking global PE model of forestry sector**
  - **Maximizes the NPV of economic surplus in timber markets**
- **Carbon sequestrarion supply curves**
  - **Introduce a range of carbon prices in the GTM**
  - **GTM is long-run model, but we focus on the first 20 years**
  - **Calculate 20 year annuity based on cumulative carbon sequestration**
- **Decompose forest carbon stocks changes into intensive margin and extensive margin**
  - **Intensive margin (manage existing forest lands for increased carbon)**
  - **Extensive margin (increase forest land cover or avoid deforestation)**

We use our framework to explore the impacts of alternative mitigation scenarios (all 27 \$/tCO_2eq)

Scenario	Forest carbon seq. subsidy		Carbon tax		Agricultural abatement subsidy
	Annex I	Non-Annex I	Annex I	Non-Annex 1	Non-Annex I
A1tax	✓	-	✓	-	-
A1tax-F	✓	✓	✓	-	-
Gtax-FS	✓	✓	✓	✓	✓
Gtax-F	✓	✓	✓	✓	-

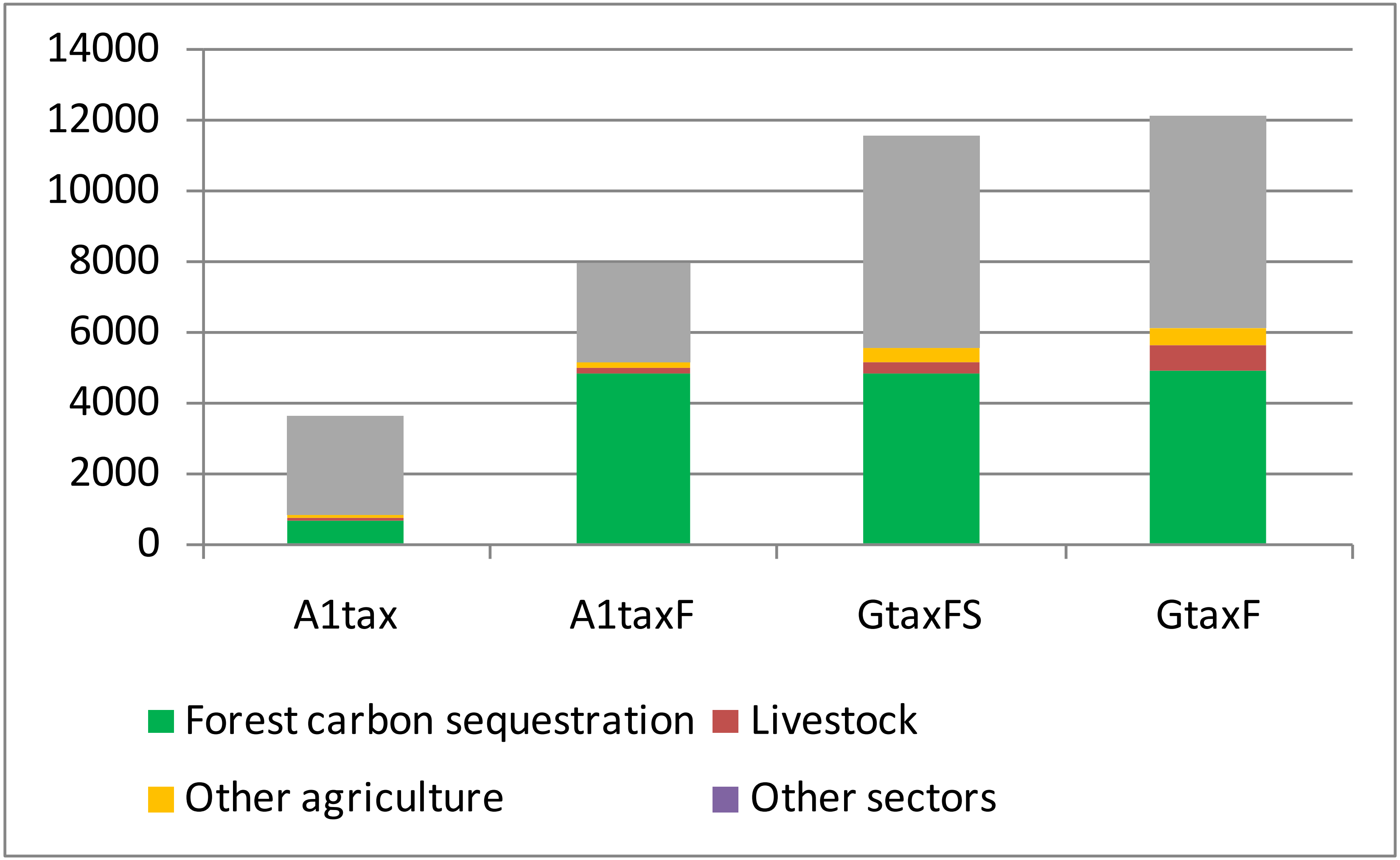
Combined mitigation possibilities can be summarized in a GE global GHG annual abatement curves (GtaxF)



Agr & forestry account for about half of GHG abatement at $27/tCO_2eq$

Note: Agricultural soil carbon not yet included

Preliminary results:
Abatement summary ($MtCO_2eq$)



Preliminary results: Abatement summary ($MtCO_2eq$)

Abatement source		Scenarios			
		A1tax	A1tax-F	Gtax-FS	Gtax-F
Total land abatement	Global Annex I	856 1,020	5,171 972	5,975 1,115	6,106 916
Forest carbon sequestration	Global Annex I	632 722	4,790 699	4,789 696	4,902 686
Agriculture	Global Annex I	224 298	381 273	797 268	1,204 230
(Livestock)	Global Annex I	106 163	229 155	389 151	745 119

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Global land-based emissions leakage
(1,020-856)/1,020*100 = 16%

Agricultural emissions leakage = 25%

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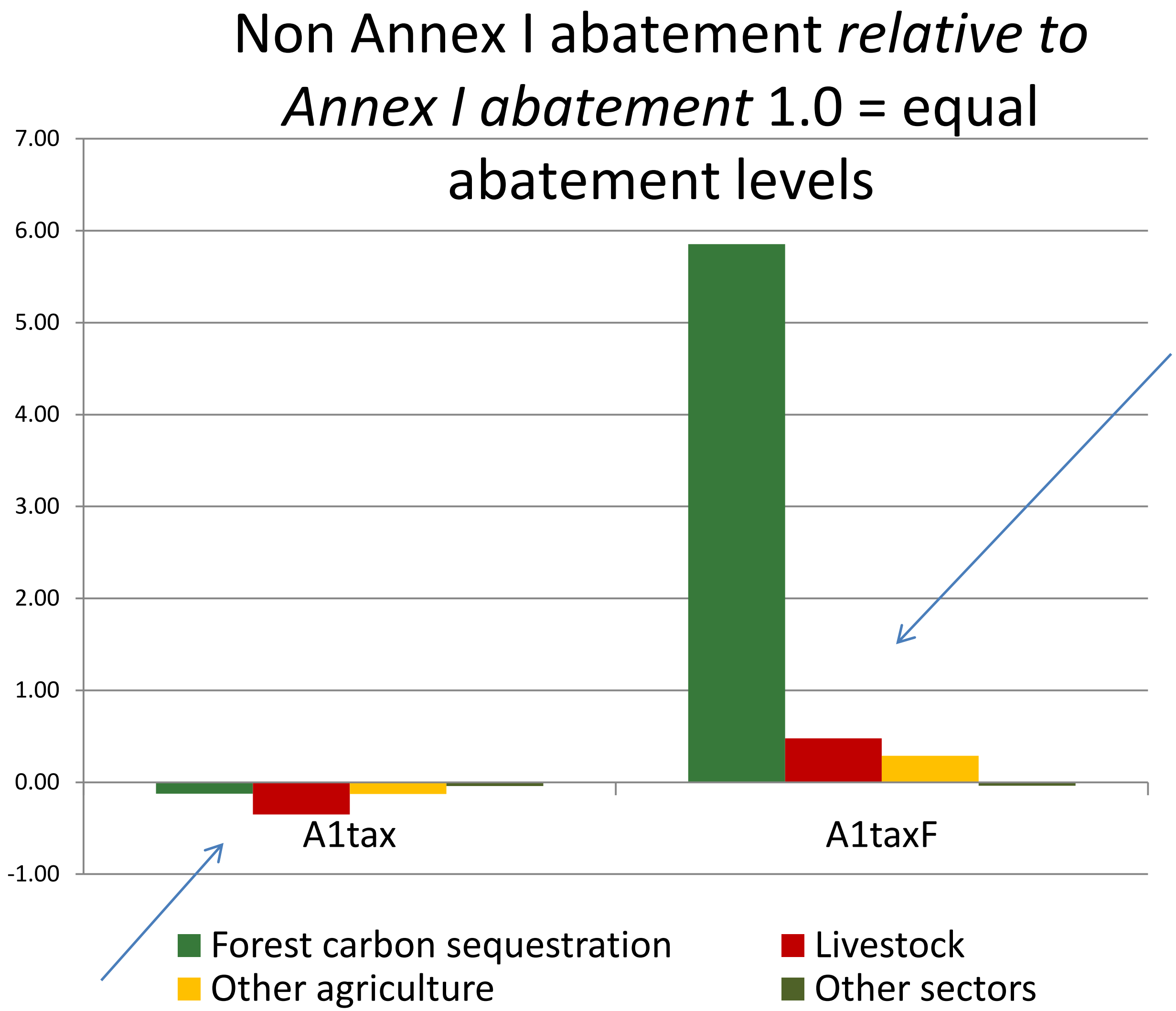
Leakage eliminated

Leakage of emissions under A1tax is eliminated with forest seq. subsidy



Leakage is eliminated; some & additional agric abatement without carbon tax when forest carbon sequestration subsidy is implemented;

Leakage = increased emissions in non-Annex 1 regions

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109% **increase in global agric mitigation**

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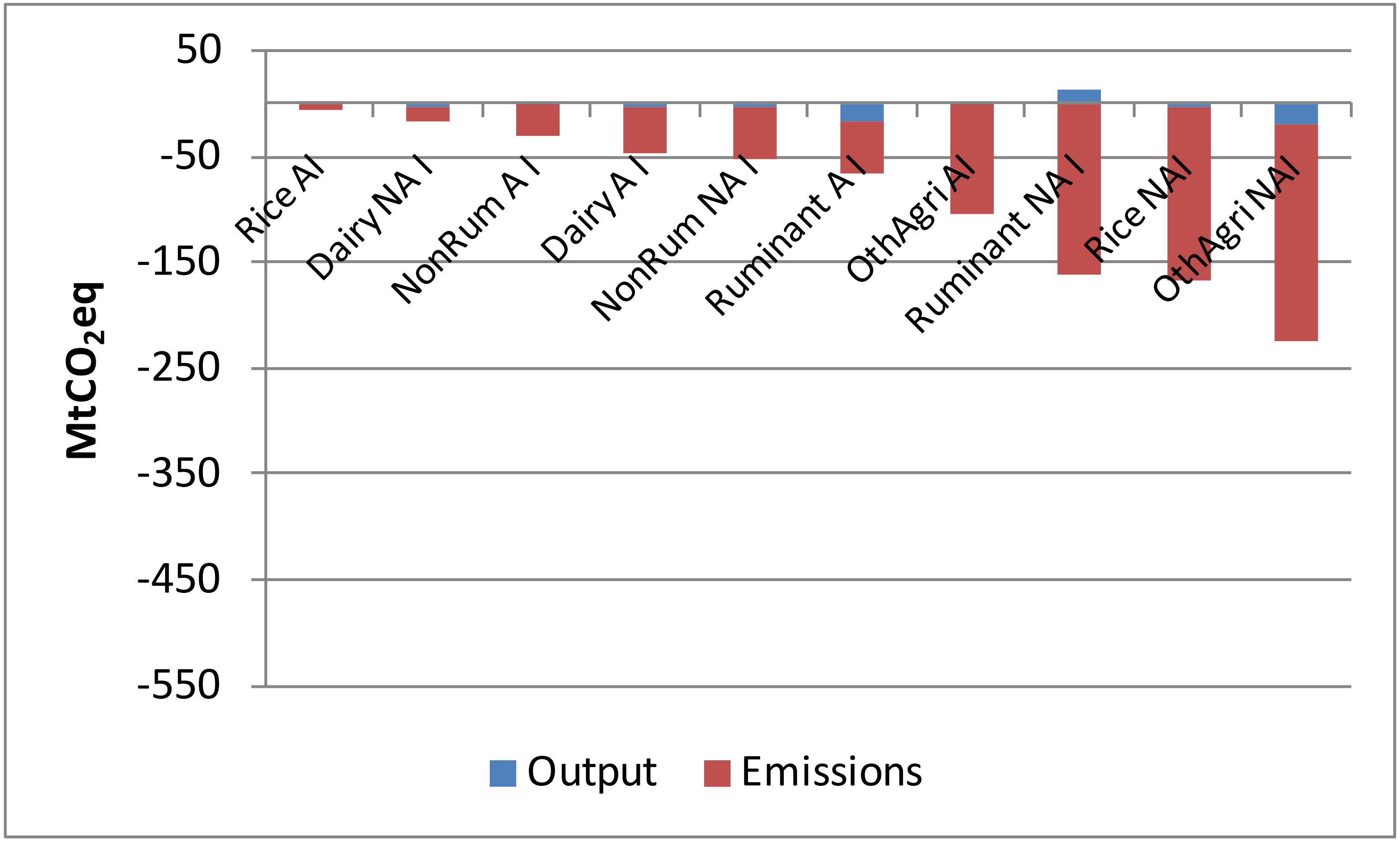
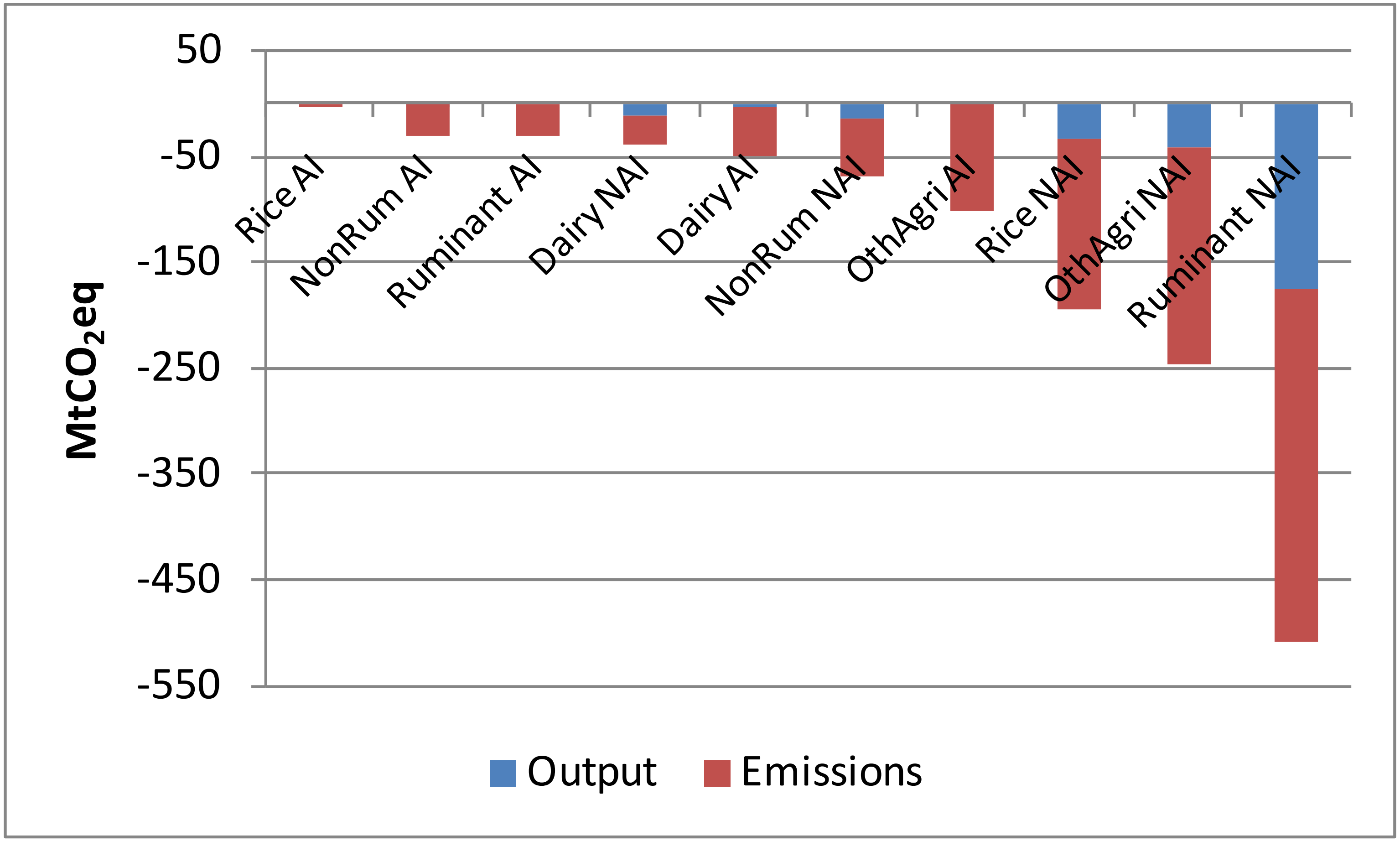
51% increase in global agric mitigation

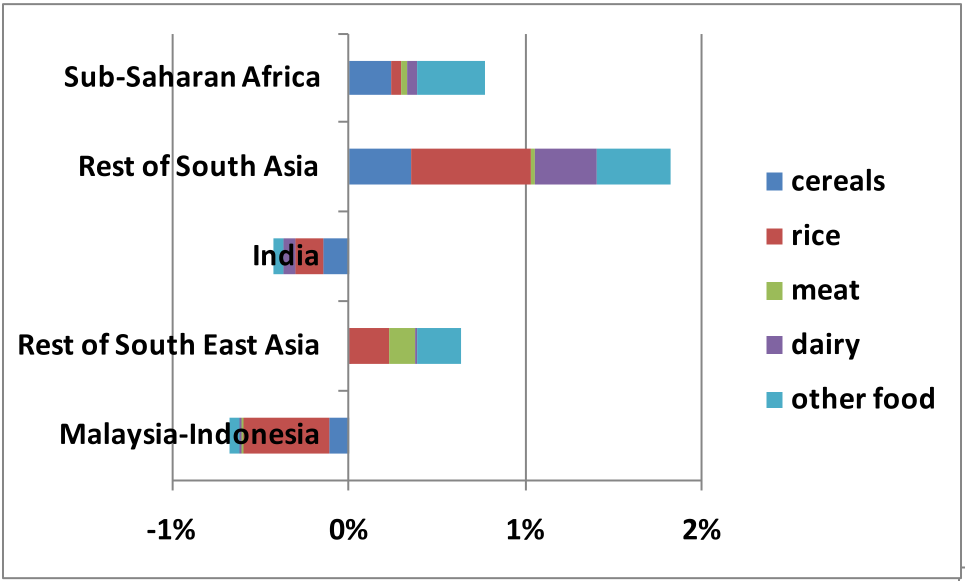
Preliminary results: Agricultural abatement Gtax-FS



Preliminary results: Agricultural abatement GtaxF



Scenario GtaxFS has more modest impacts on nutrition due to both income and price effects



Impact on ***caloric consumption***, % change in Kcal/person/day due to <u>GtaxFS</u> climate policy

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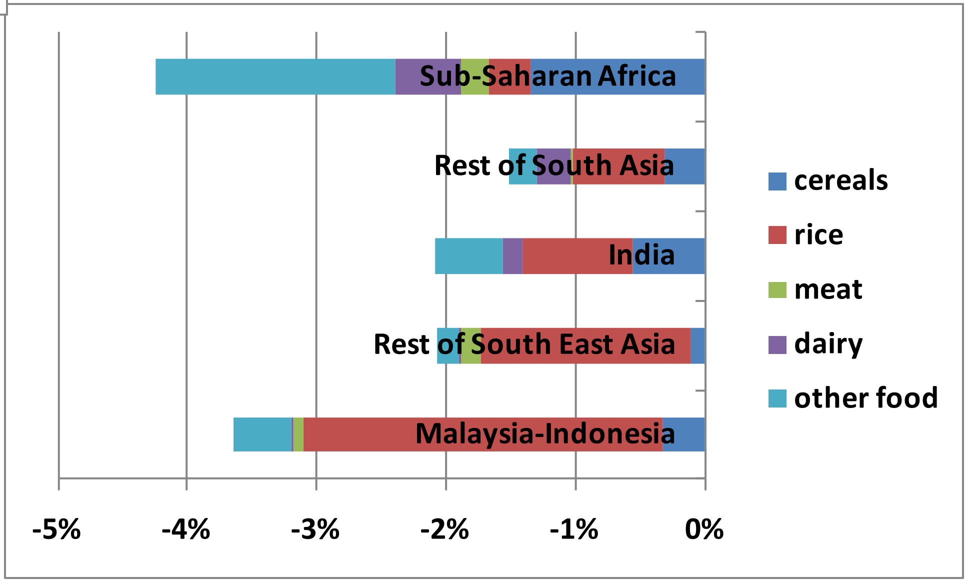

Conclusions

- Agriculture and land use change account for 1/3 of global GHG emissions, but could contribute up to 1/2 of near term mitigation
- Global forest carbon sequestration subsidy is important:
  - Large supply of low cost abatement in near term
  - Limits emission leakage from Anx I carbon policies
  - However, bids land away from agriculture and may adversely affect food security and agricultural incomes in developing countries
- Mitigation policies can drive up food prices, adversely affect food consumption in undernourished countries
  - can be addressed with subsidy mechanism

Next steps & related projects

- **More refined livestock specification**
  - **multi-product dairy sector**
  - **intensification (land-feed sub)**
  - **grazing land productivity**

- **Improve policy realism**
  - **abatement subsidy**
  - **account for own consumption in agric**

- **Revise EPA MACs**
  - **working with CSU Century modellers estimate soil C sequestration potentials**
  - **working with Steve Rose (EPRI) to augment & revise EPA MACs**

Thank you!

Forest sequestration at both the intensive and extensive margins; intensive margin is governed through 'own-use' substitution