



GTAP Project on Developing Land-use and GHG Emissions Data for use in a Computable General Equilibrium (CGE) Framework

Huey-Lin Lee
Center for Global Trade Analysis (GTAP)
Purdue University

Goals of the GTAP/EPA project

- **GTAP data base for integrated assessment**
- **Comprehensive data on land use by agro-ecological zone**
 - **Land cover**
 - **Output by AEZ**
 - **Land rents by use/AEZ**
- **Data on emission rates for the major GHG sources**
- **Data on net emission rates associated with land uses**
- **MACs for non-CO₂ sources (esp. for emissions from land uses)**

A framework for utilizing these data: GTAPE-L

- **Burniaux (2002)**

Incorporating Carbon Sequestration into CGE Models: A Prototype GTAP Model with Land Uses (GTAP Technical Paper).

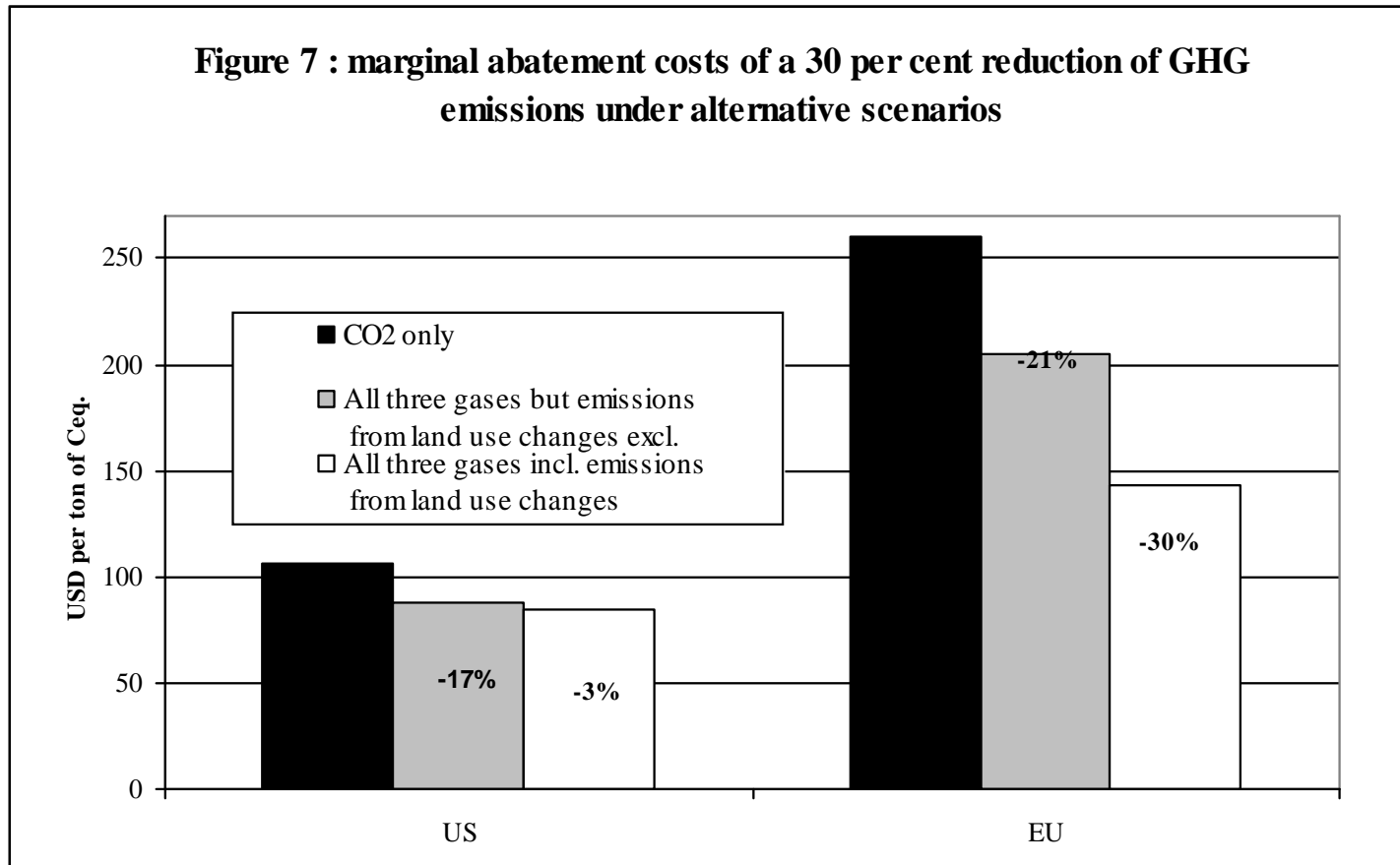
<http://www.gtap.agecon.purdue.edu/events/workshops/>

- **Illustrative simulations with a stylized data base**

Structure of Prototype Model

- **Comparative static mode**
- **11 sectors**
 - **incl. rice, crops, livestock, forestry and chemicals**
- **5 regions : US, EU, Rest of Annex 1, China+India, RoW.**
- **3 main GHGs: CO₂, CH₄ and N₂O**
- **GHGs emissions as inputs to production (CES)**
 - **MIT approach: Hyman (2001)**
 - **Calibration to EPA estimated MACs**
- **No AEZs -- just imperfect mobility across uses!**
- **Land use changes | decisions of owners and users of land**

Illustrative results...



Illustrative results: spill-over effects

Output and price changes of a 30 per cent abatement of total emissions in the US and the EU (in percentage).

	All three gases, incl. land emissions	
	US	EU
<u>Output changes</u>		
Rice	-23	-20
Crops	-4	-3
Livestock	-1	-1
Forestry	1	2
Coal	-39	-49
Oil	-5	-4
Gas	-27	-28
Oil_Pcts	-18	-7
Electricity	-6	-8
Chemicals	-3	-2
Oth_ind_ser	0	0
<u>Price changes⁽¹⁾</u>		
crops land	-3	37
crops output	6	6
forestry output	-2	-4

(1) equilibrium market prices, excluding carbon taxes/subsidies.

Degree of “land mobility” across uses

Table 9 : carbon sequestration and land mobility in the context of a 30 percent reduction of GHG emissions in the US

Scenario	value of the CET elasticity for land	marginal abatement cost (USD per ton of Ceq.)	net sinks (million tons of Ceq)
Low land mobility	0.2	87	1
Central scenario	1	85	8
High land mobility	5	53	129
Land perfectly mobile	infinite	24	287

Implications for Data Base

- **Cost-saving from sequestration highly sensitive to land mobility parameter**
 - **need to disaggregate by AEZ**
 - **reduce reliance on a single elasticity**
- **Investigate alternative treatments of land mobility (gross vs. net movements across uses)**
- **MIT approach to modeling MACs seems to work well**

Data Base Development Roadmap

- **GHG emissions data base**
 - **CO₂**
 - **CH₄, and N₂O**
 - **Sequestration**
- **The land use data base**
- **Elasticity estimates for Marginal Abatement Cost curves**

CO₂ emissions data base

- **GTAP energy volume data**
 - Tier 1 method of the revised 1996 IPCC Guidelines
 - Fuel transformation and feedstock usage
- **Working paper available on:**
<http://www.gtap.agecon.purdue.edu/events/workshops/>

CO₂ Emissions Data: Share of World Total, by Industry and Fuel

No.	GTAP sectors	Coal	Crude oil	Natural gas	Petroleum products	Gas	Industry Total
32	Petroleum, coal products	0.00	0.00	0.01	2.58	0.00	2.60
33	Chemical, rubber, plastic products	1.39	0.19	0.91	1.31	0.65	4.44
34	Mineral products n.e.c.	1.97	0.00	0.19	0.55	0.22	2.93
35	Ferrous metals	2.29	0.00	0.27	0.31	0.32	3.20
43	Electricity	27.13	0.33	4.15	3.98	4.26	39.85
47	Trade	0.05	0.00	0.06	3.47	0.26	3.84
48	Transport n.e.c.	0.06	0.00	0.12	6.99	0.03	7.21
49	Water transport	0.00	0.00	0.00	1.10	0.00	1.10
50	Air Transport	0.00	0.00	0.01	2.77	0.00	2.78
56	Public Admin., Defense, Education, Health	0.29	0.01	0.18	1.10	0.70	2.28
58	Households	1.50	0.00	0.63	11.65	2.62	16.41
	Fuel Total	37.66	0.56	7.93	41.17	12.68	

CO₂ Emissions Data: Share of World Total, by GTAP Region

No. GTAP countries	CO2 (Tg)	Significance (%)	No. GTAP countries	CO2 (Tg)	Significance (%)
19 United States	5755804	24.64	57 Rest of South African Customs Union	381898	1.63
3 China	3103448	13.29	35 France	376218	1.61
51 Former Soviet Union	2288713	9.80	49 Poland	353551	1.51
5 Japan	1202614	5.15	20 Mexico	347086	1.49
53 Rest of Middle East	939785	4.02	50 Rest of Central European Associates	335858	1.44
15 India	888057	3.80	1 Australia	319160	1.37
36 Germany	878202	3.76	27 Brazil	286708	1.23
37 United Kingdom	612816	2.62	8 Indonesia	279566	1.20
18 Canada	523484	2.24	44 Spain	267051	1.14
40 Italy	438188	1.88	55 Rest of North Africa	244054	1.04
6 Korea	433267	1.85	42 Netherlands	239136	1.02

CH₄ and N₂O emissions data base

- **EPA data**
 - Tier1 and Tier 2 methods
- **mapping of emissions sources to GTAP:**
 - Mapping to sector
 - Mapping to “drivers”, i.e. inputs or output

Mapping of CH₄ emissions data to GTAP

Emissions sources (EPA data)	Mapping to GTAP
Natural gas and oil system	
-- production	Natural gas sector
-- transmission	
-- distribution	
-- processing operation	
Livestock enteric fermentation	
Solid waste landfilling	Other services
Coal mining	Coal
-- types of coal	
-- mining practices	
Livestock manure management	Cattle, sheep and goats, horses
Water waste treatment	
-- municipal	Water
-- industrial	Chemical, rubber, plastic products
Rice paddy	Paddy rice
Combustion	
Agricultural residue burning	

Mapping of N₂O emissions data to GTAP

Emissions sources (EPA data)	Mapping to GTAP
Agriculture soils	
-- use of fertilizer	paddy rice; wheat; cereal grain n.e.c.; vegetables, fruits, nuts; oil seeds; sugar can and sugar beet; plant-based fibers; crops n.e.c.
-- use of manure	Crops n.e.c.; cattle, sheep and goats, horses
Industrial process (e.g., PVC prod)	Petrol-chemical sector
Combustion	
-- stationary	
-- power plant	Electricity sectors
-- boiler	Manufacturing secotrs
-- mobile (transport)	Land/water/air transport
Manure management	Cattle, sheep and goats, horses

Sequestration Data

- **EPA**
- **Other specialists**

Land use data base

- **Available data sources**
 - **ERS/USDA**
 - **FAO**
 - **U. of Wisconsin**
 - **RIVM IMAGE Team**

The land-use matrix for a geopolitical region proposed in the workshop discussion

AEZ	Land classes in region r							L ₀	L ₁
	Forest ₁	Forest _T	Livestock	Crop ₁	Crop _N		
AEZ ₁									
....									
....									
....									
AEZ _M									

Land Cover in the United States by Agro-Ecological Zone in 1997 (1000 ha)							
Compiled by Roy Darwin, September 10, 2002							
	Agro-Ecological Zone						
Cover	1	2	3	4	5	6	Total
Cropland	3,348	24,292	40,405	62,482	32,405	21,224	184,156
Grassland	15,891	51,656	42,032	29,546	25,484	17,977	182,587
Conifer Forest	26,256	36,974	35,624	10,437	7,633	10,261	127,186
Non-Conifer Forest	49	1,846	17,429	30,266	22,721	13,367	85,678
Mixed Forest	2,669	2,561	26,711	9,945	13,194	42,304	97,384
Open Forest	0	8	503	832	29	11	1,382
Shrubland	67,126	74,378	19,120	4,725	451	33	165,832
Tundra	11,323	8,422	3,439	15	3	0	23,202
Built-Up Land	441	2,119	4,072	6,734	3,220	3,447	20,032
Other Land	8,143	13,445	5,262	283	609	749	28,491
Total	135,247	215,699	194,596	155,265	105,749	109,374	915,930

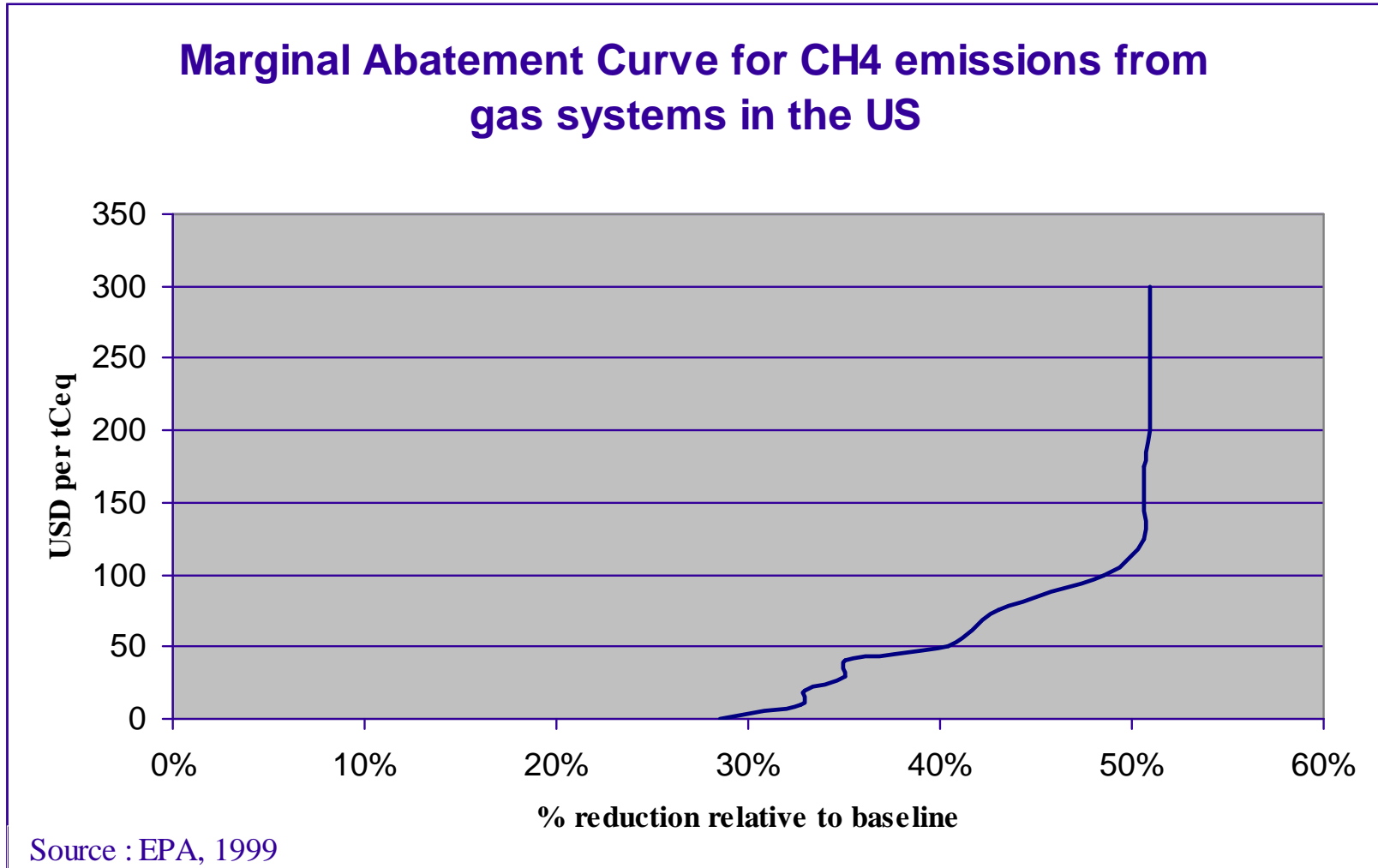
RIVM IMAGE data

Land Cover in the United States by Agro-Ecological Zone in 1995 (1000 ha)							
Compiled by Bas Eickhout, October 3, 2002							
	Agro-Ecological Zone						
Cover	1	2	3	4	5	6	Total
Cropland	0	2,305	16,021	188,287	63,941	118,327	388,880
- Rainfed crops:							
- Grass and fodder	0	1,668	8,443	92,140	30,796	80,128	213,175
- Temperate cereals	0	0	2,045	31,002	7,656	12,543	53,246
- Rice	0	0	72	361	185	230	848
- Maize	0	1	1,217	34,196	10,474	5,038	50,925
- Tropical cereals	0	146	379	3,786	1,856	875	7,042
- Pulses	0	6	231	564	32	106	939
- Roots and tubers	0	3	132	305	10	18	468
- Oil crops	0	457	2,849	18,729	11,769	16,559	50,363
Extensive grassland (low productive agr. land)	8,497	12,521	3,099	3,398	518	542	28,576
Tundra and wooded tundra	25,002	27,366	11	0	0	0	52,379
Boreal forest	280	43,769	51,317	5	0	0	95,370
Cool conifer	0	0	4,853	1,167	0	0	6,020
Temperate forest	0	0	7,894	33,942	45,217	6,432	93,485
Warm mixed forest	0	0	0	0	2,286	17,629	19,915
Steppe	46,368	64,583	39,195	20,591	233	1,286	172,256
Shrubland	1,045	1,299	1,285	5,823	3,459	265	13,176
Savannah	0	0	0	0	0	128	128
Regrowth forest (after timber or abandoning)	0	0	1,914	11,129	5,320	3,824	22,187
Built-Up Land	105	101	209	2,882	2,411	2,147	7,854
Other Land	17,148	4,291	260	0	0	2,577	24,276
Total	98,444	156,235	126,057	267,224	123,384	153,158	924,502

Marginal Abatement Cost Curves

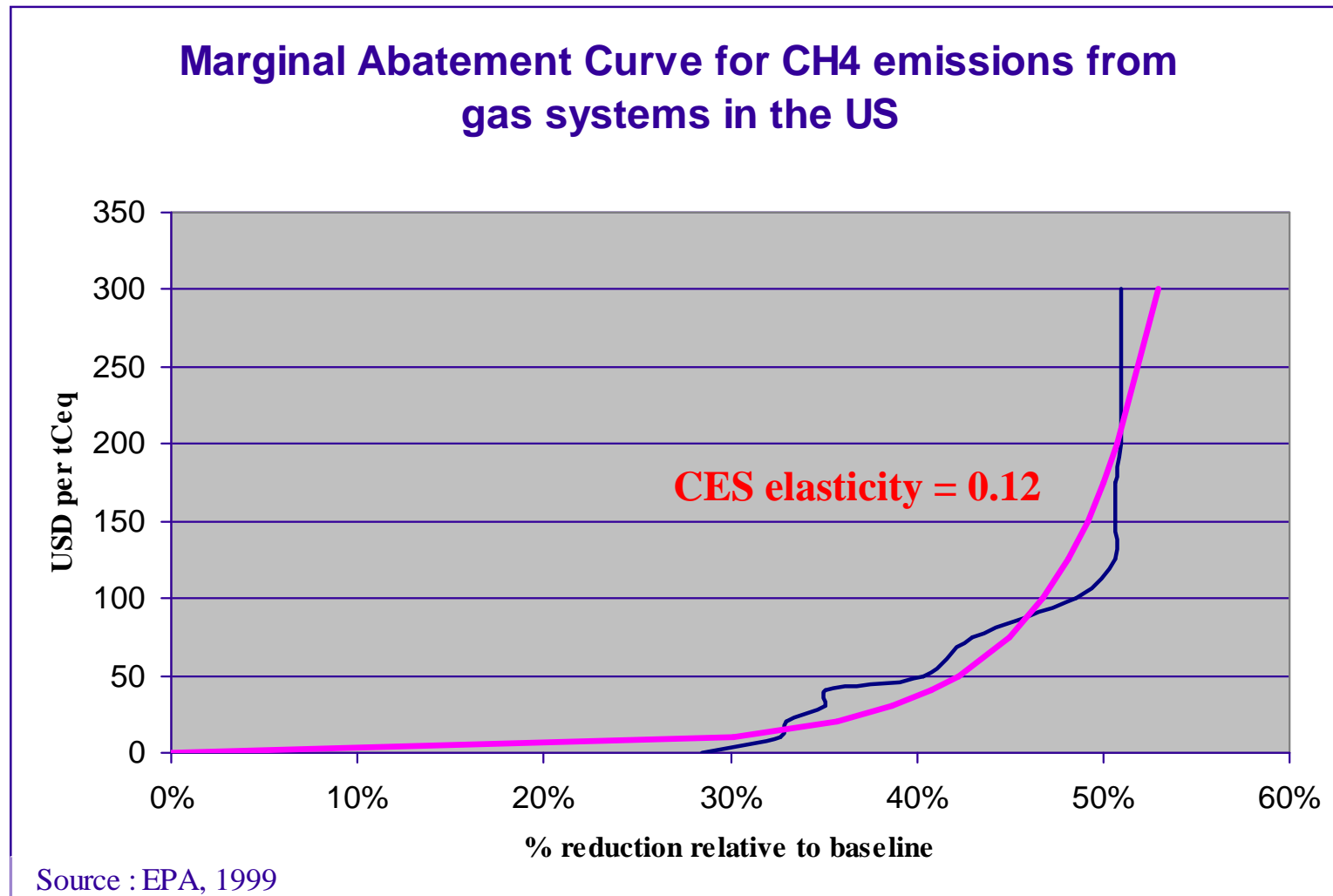
- **Elasticity estimates of marginal abatement costs (MACs)**
 - EPA
 - Hyman (2001)

EPA data on MAC



The MIT approach to modeling MACs

(see Hyman, 2001)



End Products of This Project

- **GTAP land use data base by AEZ**
- **GTAP GHGs data base by activity and net-puts (drivers)**
- **GTAPE-L model template to ensure that these data fit into a coherent CGE framework**

Update of Progress and Activities

- **Broadcast and communications**
- **The MIT Workshop:**
 - Availability of land use data
 - GHGs emissions data base

<http://www.gtap.agecon.purdue.edu/events/Workshops/>

Suggestions and Comments ?!