Green House Gas Mitigation Policy, Bio-fuels and Land-use Change

- a Dynamic Analysis

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Poster prepared for presentation at the Agricultural & Applied Economics Association 2010 AAEA, CAES, & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010

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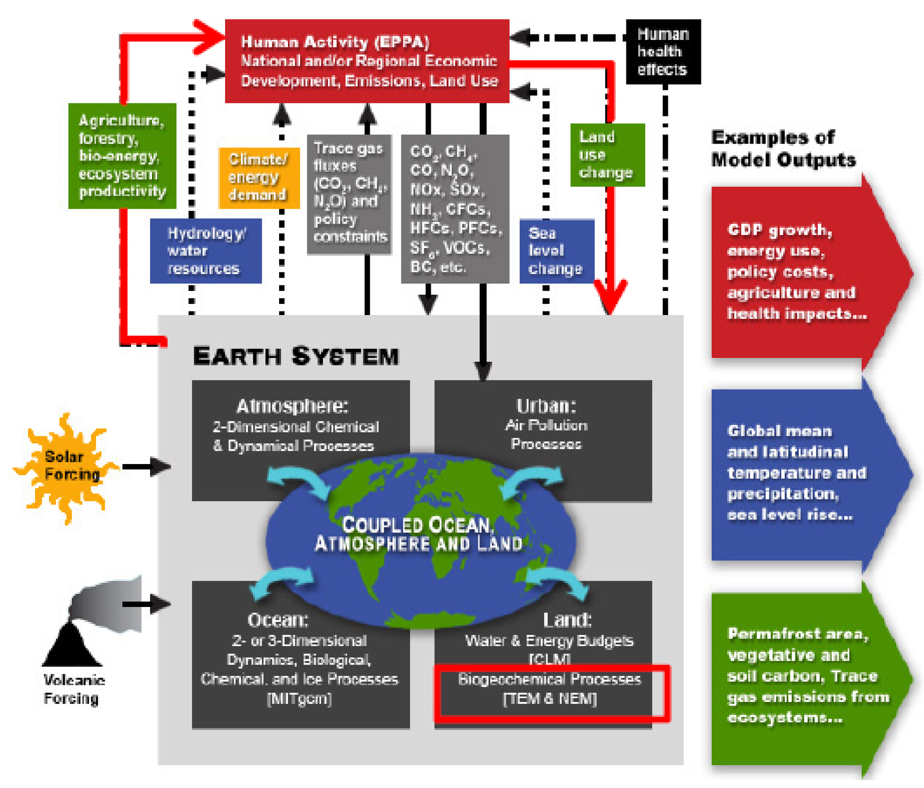
1. Motivation

Agricultural green house gas (GHG) emissions, GHG mitigation policy, climate, biofuels, land-use changes and economic activities are highly interactive. Previous investigations have, at best, loosely linked models that describe these components or more often have focused on one way interactions.

Within the MIT Integrated Global System Model (IGSM) framework, we develop a dynamic linkage between an complex economic model– MIT Emissions Prediction and Policy Analysis (EPPA) model and the Terrestrial Ecosystem Model (TEM) from Marine Biology Laboratory (MBL) to study the dynamic interactions of greenhouse gas emissions policy, land-use activities and the implications for second generation biofuels production.

2. Methodology

2.1 IGSM Review



EPPA is a multi-sector, multi-region computable general equilibrium (CGE) model of the world economy with 16 regions and 21 sectors. EPPA simulates the economy recursively at 5-year intervals from 2000 to 2100.

TEM is an ecosystem model that describes carbon and nitrogen dynamics of plants and soils for terrestrial ecosystems of the globe. The TEM operates on a monthly time step and at a grid-cell spatial resolution of 0.5 x 0.5 latitude by longitudes.

Figure 1. IGSM - Integrated Global System Modeling Framework (Source: http://globalchange.mit.edu/igsm/index.html)

2.2 Dynamic linkage

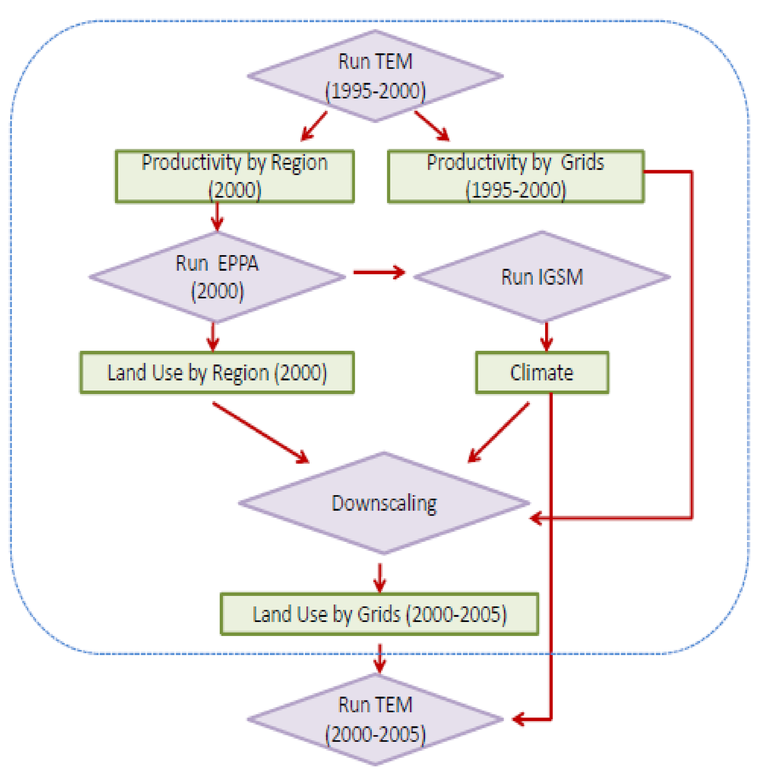


Figure 2. EPPA -TEM linkage

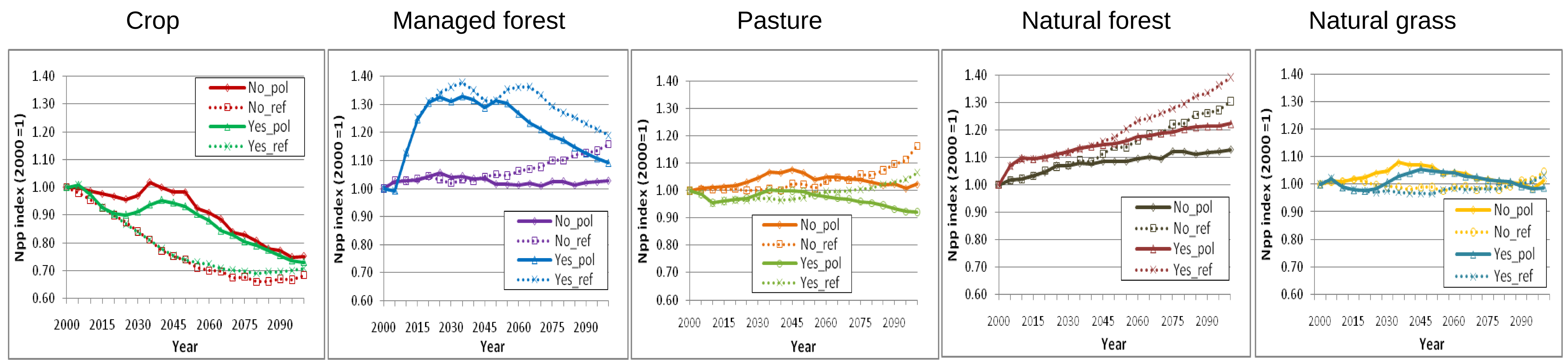
a. We aggregate productivity changes from TEM to the regional scale for EPPA.
b. EPPA simulates green house gas emissions as input to IGSM and estimates regional land use.
c. IGSM simulates future climate: temperature, precipitation, CO_2 and O_3 concentrations.
d. A cross section econometric land use model is used to downscale regional land use information from EPPA to the grid level of TEM.

2.3 Scenario analysis

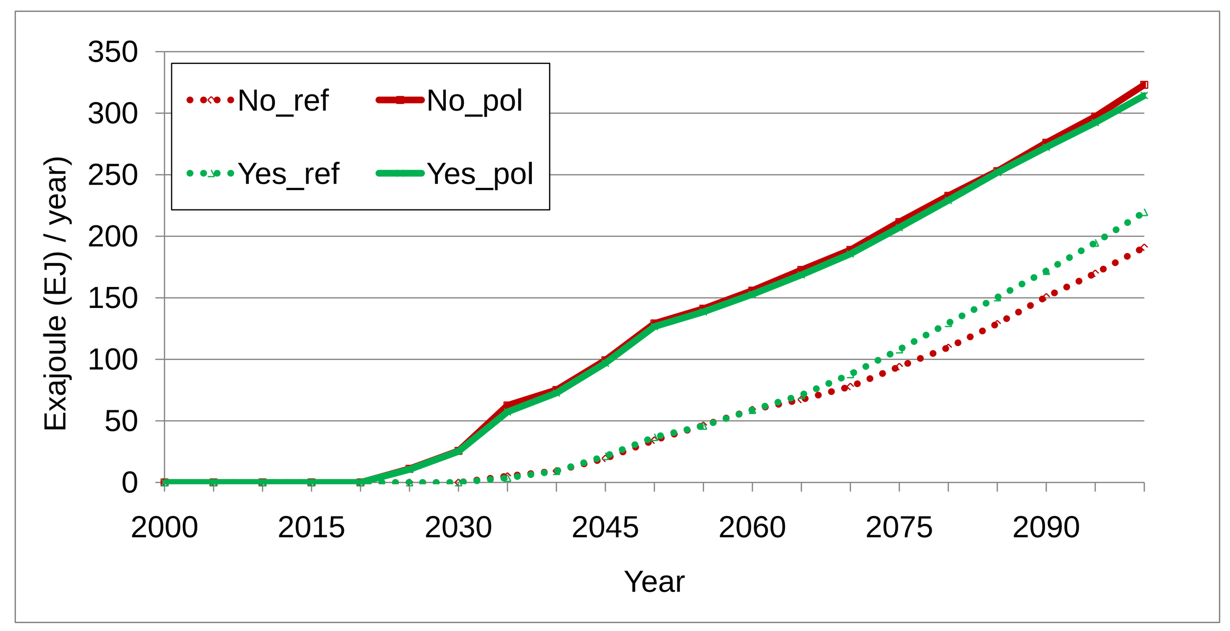
Linkage scenario: Yes -- the dynamic linkage
No -- the loose linkage in Wang (2008) and Mellio et al (2009)
Policy scenario: Ref -- no policies to mitigate green house gas emissions
Pol -- 550 ppm CO2 stabilization policy

3. Results

3.1 Global land productivity (area weighted NPP index)



3.2 Biomass energy production (EJ/year)

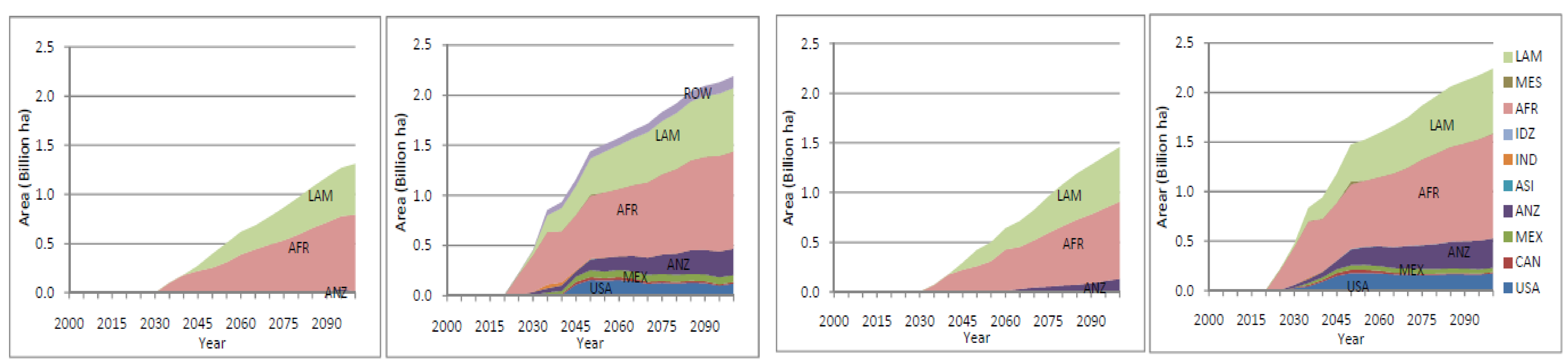


3.3 Global land use in 2000, 2050 and 2100 (billion ha)

	2000	2050				2100			
		No_ref	Yes_ref	No_pol	Yes_pol	No_ref	Yes_ref	No_pol	Yes_pol
Crop	1.61	2.25	2.27	1.84	1.91	2.05	2.05	1.82	1.85
Biomass	0.00	0.40	0.42	1.44	1.54	1.31	1.46	2.19	2.31
Pasture	2.61	2.61	2.68	2.18	2.20	1.87	1.86	1.44	1.48
Managed Forest	1.54	1.19	1.07	1.10	0.91	1.35	1.23	1.28	1.13
Natural Grass	0.95	0.68	0.66	0.55	0.53	0.64	0.61	0.50	0.47
Natural Forest	3.58	3.16	3.20	3.17	3.21	3.08	3.08	3.06	3.05

3.4 Regional land used for bio-fuel production (billion ha)

No_ref No_pol Yes_ref Yes_pol



4. Conclusion

- With dynamic linkage, managed forest land and natural forest land are more productive, pasture land less productive, little effect on productivity of crop land and natural grass land under both the policy and reference case.
- Climate mitigation policy leads to large-scale bio-fuels energy. As a result, managed forest, pasture, natural forest and natural grass land are diverted to produce biomass. Dynamic linkage results in further reduction of managed forest, especially in Africa, Latin America and United States.