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Global Land Use Changes and Consequent CO_2 Emissions due to US Cellulosic Biofuel Program: A Preliminary Analysis

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1. Introduction

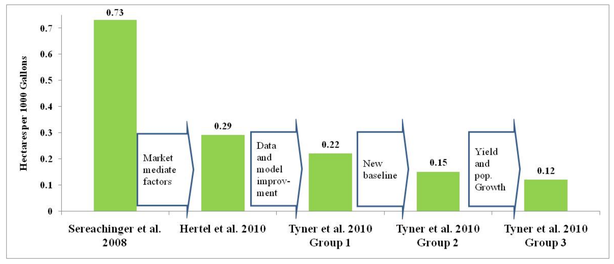
The land use consequences of US biofuel programs and their contributions to GHG emissions have been the focal point of many debates and research studies in recent years. However, most of these studies focused on land use emissions due to the first generation of biofuels such as corn ethanol, sugarcane ethanol, and biodiesel. However, only a few and incomplete attempts have been made to estimate these emissions for second generation technologies which convert cellulosic materials into liquid fuels.

The land use impacts of producing biofuels from cellulosic materials could be more complicated than corn ethanol. Currently, technologies for producing biofuels from cellulosic materials are not commercially available, so there is no market data on which to base the analysis, and there is little farmer experience in producing the needed feedstocks. For these reasons it is important to provide a comprehensive analytical framework to assess a wide range of alternative possible cases which may come about in the future.

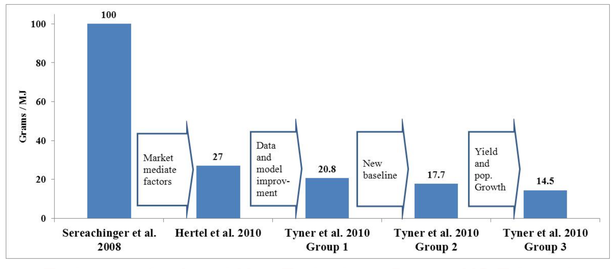
2. Objectives

This research develops a numerical general equilibrium model to investigate GHG emissions due to land use changes induced by producing biofuels from cellulosic materials.

3. Existing Estimates for Corn Ethanol

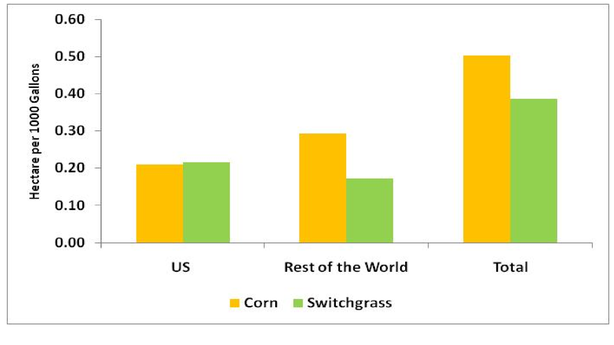


Estimates for Land Requirements to Support US Ethanol



Estimates for Land Use Emissions Due to US Ethanol

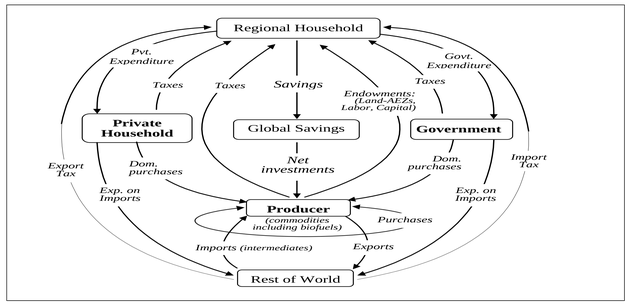
4. Land Use Estimates Made by EPA for Corn Ethanol and Switchgrass



5. Numerical General Equilibrium Model

- A Computational General Equilibrium Model was developed to investigate the global land use impacts of producing biofuels from cellulosic materials.
- The Model is a special version of the Global Trade Project Model (GTAP) developed at Purdue University. It is based on the latest version of the modified model for biofuel analyses (GTAP-BIO-ADV developed by Tyner et al., 2010) and includes the following new major extensions and improvements:
  - It uses the latest version of GTAP data base which depicts the world economy in 2004,
  - It covers production of consumption of the first and second generation biofuels,
  - Adds greater flexibility in acreage switching among crops in the US in response to price changes,
  - Include an endogenous yield adjustment for cropland pasture in response to changes in cropland pasture rent.

6. An Overview of GTAP Model



7. Modifications in GTAP Database

- Introduced 2004 global production, consumption, and trade for first generation biofuels including corn ethanol, sugarcane ethanol, and biodiesel.
- Updated land use, land cover, and land rent headers to 2004.
- Modified the basic GTAP database as was done previously in older version:
  - Split GTAP food industry into food and feed industries,
  - Split GTAP vegetable oil into crude and refined vegetable oil industries.
- Introduced by-products into the 2004 database.
- Introduced cellulosic feedstock industries into the model:
  - Corn stover industry which collects corn stover and delivers collected materials to biofuel producers,
  - Miscanthus industry which produces miscanthus and delivers it to biofuel producers.
- Introduced a biofuel (bio-gasoline) processing industry for each feedstock with identical cost structures.

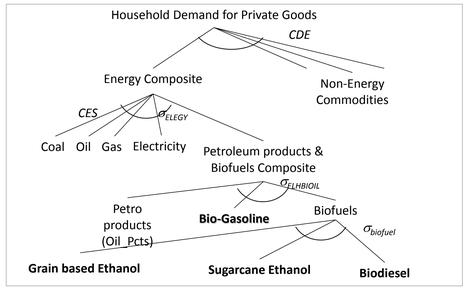
8. Cost Structures (shares) of Feedstock Industries

Cost Items	Corn Stover	Miscanthus
Fertilizer	15.3	11.6
Transportation	23.4	10.9
Fuel	2.0	4.0
Payments to seed company	0.0	8.1
Other costs	7.0	10.0
Labor	10.5	18.
Land	0.0	2.4
Capital (including profit)	41.7	35.0
Total	100.0	100.0

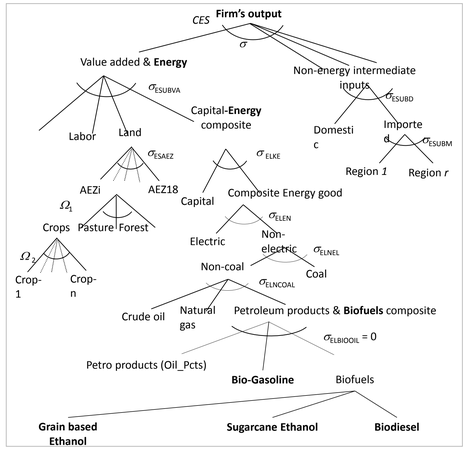
9. Cost Structures (shares) of Advanced Biofuels

Costs Items	Cost shares
Feedstock	28.2
Energy	1.4
Other costs	23.3
Labor	3.3
Capital	43.8
Total	100.0

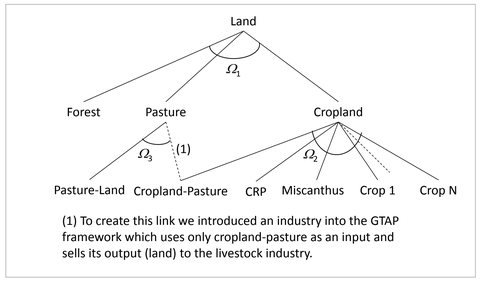
10. Modifications in GTAP-BIO Model



Household Demand Structure



Demand Structure of Firms

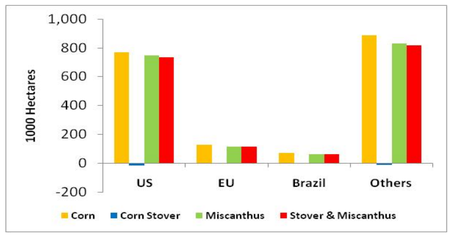


Land Cover and land Use Activities

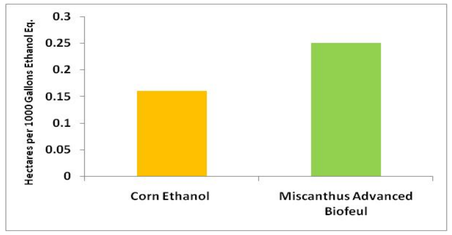
11. Simulation Scenarios

- An increase in corn ethanol production from its 2004 level (3.41 BG) to 15 BG, off of the 2004 database.
- An increase in production and consumption of Bio-Gasoline produced from corn stover by 6 BG (or 8.97 BG ethanol equivalent), off of 15 BG corn ethanol.
- An increase in production and consumption of Bio-Gasoline produced from miscanthus by 4.7 BG (or 7.03 BG ethanol equivalent), off of 15 BG corn ethanol.
- Increases in stover and miscanthus biofuel by 6 BG and 4.7 BG simultaneously, off of 15 BG ethanol.

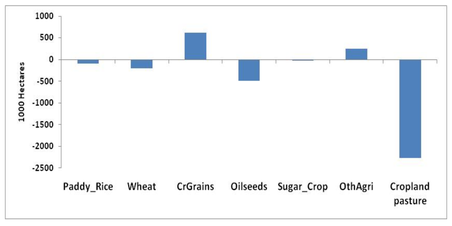
12. Preliminary Results



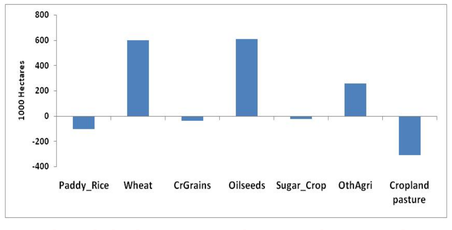
Expansion in Cropland Due to Biofuels



Land Requirements for Corn Ethanol and Bio-Gasoline Produced from Miscanthus



Changes in US Harvested Areas Induced by Miscanthus Advanced Bio-gasoline



Changes in Global Harvested Areas (Except for US) Induced by Miscanthus Advanced Bio-gasoline

13. References

Tyner, W., F. Taheripour, Q. Zhuang, D. Birur, and U. Baldos, (2010). "*Land Use Changes and Consequent CO2 Emissions due to US Corn Ethanol Production: A Comprehensive Analysis, A Report to Argonne National Laboratory*, Department of Agricultural Economics, Purdue University.

Taheripour, F., and W. Tyner, (2011) Global Land Use Changes and Consequent CO_2 Emissions due to US Cellulosic Biofuel Program: A Preliminary Analysis, *A Report to Argonne National Laboratory*, Department of Agricultural Economics, Purdue University.

14. Acknowledgment

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