GLOBAL ECONOMIC AND ENVIRONMENTAL INTERACTION OF LIVESTOCK AND CLIMATE CHANGE

Luis M. Pena-Levano
Department of Agricultural Economics
Purdue University, West Lafayette, IN 47907
Email: lpenalev@purdue.edu

Dr. Farzad Taheripour
Department of Agricultural Economics
Purdue University
Email: tfarzad@purdue.edu

Dr. Wallace E Tyner
Department of Agricultural Economics
Purdue University
Email: wtyner@purdue.edu

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LUIS PEÑA-LEVANO; Dr. FARZAD TAHERIPOUR; Dr. WALLACE E. TYNER
AGRICULTURAL ECONOMICS DEPARTMENT, PURDUE UNIVERSITY

ABSTRACT

The livestock sector and climate change are deeply connected, providing continuous feedbacks. Livestock contributes significantly to greenhouse gases emissions across its production chain. Variation in climate can affect pastureland as well as forest and cropland productivities raising land competition. Mitigation policies target emission reduction which may have effects on the output levels of this carbon-intensive industry. We evaluate these interactions using our new version of a computable general equilibrium entitled GTAP-BIO-FCS which is suitable for the economic analysis of mitigation policies such as forestry sequestration (FCS), carbon tax and biofuels. Our results suggest that the livestock sector is affected by climate change depending on land required for FCS, the land needed for agriculture due to overall decreases in crop productivity, the imposed carbon tax rate, changes in real income and private consumption pattern, and biofuel policies.

INTERACTIONS

LIVESTOCK → CLIMATE CHANGE

- Methane emissions from animal stock (ruminants)
- GHG emissions from pastureland and land use change

CLIMATE CHANGE → LIVESTOCK

- **Direct effects:**
  - It increases heat stress
  - It affects pastureland productivity due to changes in weather
- **Indirect effects**
  - It also affects crop productivity and crop mix.

MITIGATION POLICIES → LIVESTOCK

- Incentives for forest expansion can reduce land available for livestock
- Mitigation policies that target emission reductions can affect this carbon-intensive industry

Objective

Our study aims to highlight the main implications that climate change has for the livestock industry with and without emissions reduction policy.

CONTRIBUTION OF OUR STUDY

1. It provides a more comprehensive understanding of the climate change interaction with the livestock sector
2. It highlights the implications of climate change on the livestock industry with and without emission reduction policies
3. It shows the importance of including the climate change induced land cover productivities (i.e. crops, pasture land and forest cover) on evaluating the effects on the livestock sectors
4. It examines and differentiates the climate change effects on ruminant vs. non-ruminant animals
5. It illustrates the trade-off on livestock impacts of each mitigation policy
6. It shows how the economic impacts for each region of the world varies depending on the policy

METHODOLOGY

We use our new extension of a Computable General Equilibrium (CGE) model called **GTAP-BIO-FCS.** This static version represents the world economy of 2004 and includes the so-called Kyoto greenhouse gases. This new model incorporates **forest carbon sequestration** (FCS), **carbon tax and biofuels** which make it a suitable model for climate change mitigation policy analysis.

CGE model — It combines both sides of the economy (production and consumption) into a multiregional framework.

- The database contains:
  - ✓ 19 regions and 18 agro-ecological zones (AEZs)
  - ✓ 43 sectors including agriculture (and biofuels), manufacture and services
  - ✓ It includes forest carbon storage and GHG emissions
  - ✓ It differentiates livestock into ruminants (beef and dairy farm cattle) and non-ruminant animals.
  - ✓ It includes biofuel byproducts (i.e. Distilled Grains with Solubles [DDGS]) which are used for livestock feedstocks.

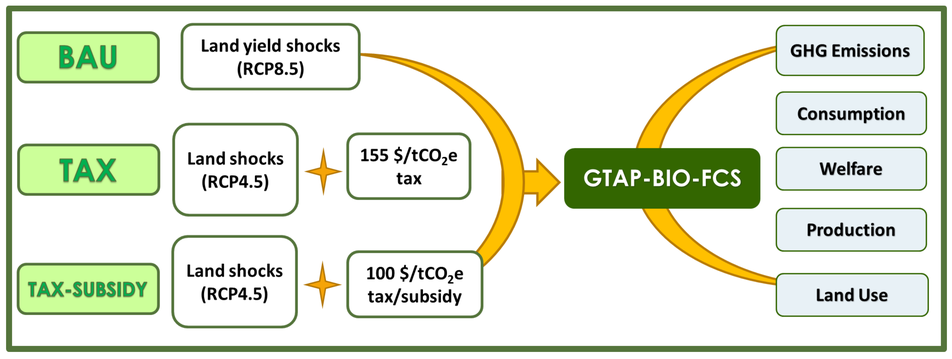
SCENARIOS

To fulfill our objective, we consider a business-as-usual (BAU) scenario and compare it to two different mitigation scenarios.

1. ***BAU* scenario:** There are efforts to reduce GHG emissions. There are no mitigation policies. This case follows the RCP 8.5 scenario of the IPCC report which establishes the world behaves as usual.
2. ***TAX* scenario**: We impose a tax on emissions to reduce net GHG emissions by 50% globally following the RCP 4.5 ['mitigation'] scenario. This uniform tax (in $/tCO$_2$e) is applied to all emissions.
3. ***TAX-SUBSIDY* scenario**: We implement a tax on emissions and an equivalent FCS subsidy to reduce global net emissions by 50%.

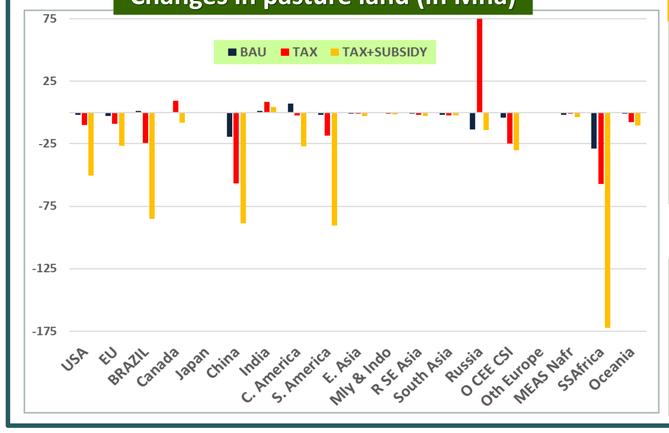
For each scenario we implement the climate change effects on cropland, pasture and forest cover as exogenous shocks on land productivity of type of land.

IMPLEMENTATION



GTAP-BIO-FCS MODEL RESULTS

Changes in pasture land (in Mha)



BAU

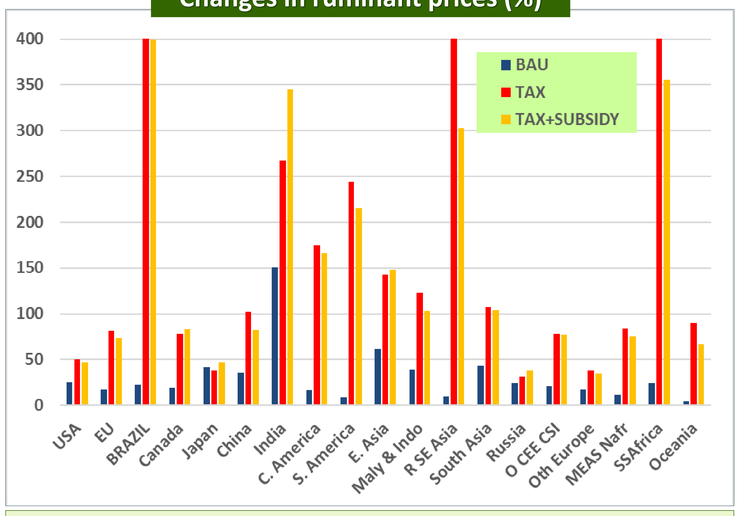
Expansion of land occurs in many regions due to the less productive land.
Cropland takes away land mainly from pasture.
As a result, there are huge increases in livestock prices

Mitigation

Due to the high subsidy FCS incentive there is substantial forest expansion, especially for developing economies. This decreases pasture land in many regions.

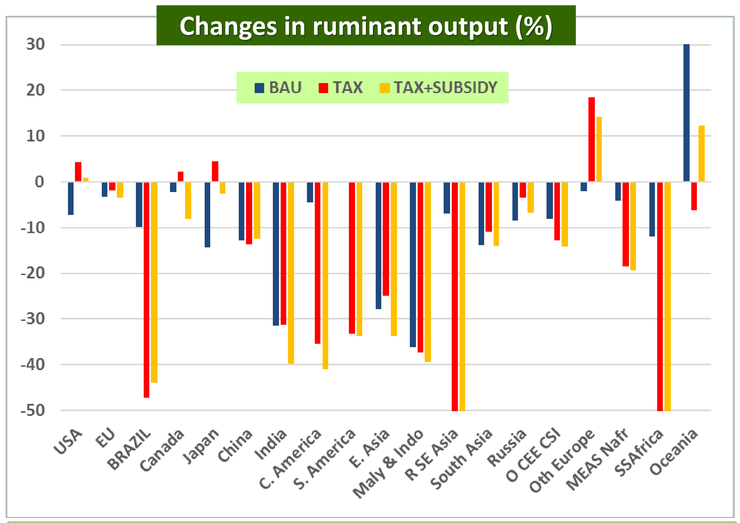
GTAP-BIO-FCS MODEL RESULTS

Changes in ruminant prices (%)



- Imposing a tax regime ($150/tCO$_2$e) to reduce net emissions by 50% increases drastically livestock prices (especially for ruminant and dairy sector), especially for regions with high carbon intensive production.
- The carbon tax reduces private consumption and income across regions. Changes in prices are twice larger than for the non-ruminant sector.
- FCS subsidy decreases the carbon tax to 100$/tCO2e but motivates land competition, which motivates increases in prices.

Changes in ruminant output (%)



- **In the BAU case:** regions with land intensive production suffer increases in prices for dairy and beef products which lead to reductions in outputs. Similar situation for the non-ruminant sector.
- **In the mitigation cases**: due to the high carbon tax on emissions, ruminant sectors are heavily penalized. The increase in prices due to the taxes lead to reductions on outputs for both ruminant and non-ruminant sectors.

CONCLUSIONS

Our study suggests if the economy behaves as usual, there are changes in regional land covers. Expansions in cropland at expenses of pasture occur in many regions due to the less productive ag. land.
Imposing a tax regime to reduce emissions by 50% increases drastically livestock prices because livestock sector would need to contribute about 16% globally to this effort. This is especially true for regions with high carbon intensive production. Ruminant sectors are particularly penalized due to the methane emissions.
When implementing the FCS subsidy plus the carbon tax, FCS decreases the contribution of ruminant sector (13%) in the emission reduction. However, due to the expansion in forest, there is fierce competition for land. Global afforestation occurs at the expense of pasture which ultimately increases livestock prices. Technological progress could alter our conclusions and help to reduce the costs of mitigations policies