GTAP-AEZ

Land use application of the GTAP Model

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Presented by

The Gorgeous Tenacious Amusing Persons from the Asian-European Zone

About GTAP-AEZ

- GTAP-AEZ is a global economic commodity and trade model.

- Important for analyzing the environmental impacts of economic activities and policies, such as:

  →Effect of crop productivity shocks or bio-fuel expansion on land use;

  →Impact of agricultural productivity growth on global GHG emissions from land cover change;

Some key distinctions from the Standard Model (Hertel, 1997)

The GTAP-AEZ database and theoretical structure differs from the standard GTAP model → includes additional elements to allow analysis of land use and emissions.

(1) Allows for land to be a heterogeneous endowment:

→ regional land endowment split into Agro-Economic Zones (AEZs) that differ by growing period and climatic zones.

(2) Recognizes that land may not be freely mobile between alternative uses:

→ mobility of land is constrained by a Constant Elasticity of Transformation (CET) frontier;

→ different returns to land in alternative uses

(3) Allows for changes in crop yields by extensive and intensive margins.

(4) Allows for changes in emissions from different land use.

Land use application based on Villoria *et al.* (2013)

Scenario 1:
Regional productivity shock

- IDN experience productivity growth rates of 39%;
- Productivity in other crops within IDN and Rest of the World (ROW) assumed unchanged.

- **Key Result:**
  → Regional deforestation;
  → Global forest reversion;
  → Lower global emissions.

Scenario 2:
Global productivity shock

- IDN experience productivity growth rates of 39%;
- Productivity shocks to other crops within IDN and Rest of the World (ROW) according to estimates of Fischer *et al.* (2012).

- **Key Result:**
  → Net forest reversion locally and globally;
  → Net reduction in emissions locally and globally.

The Land Policy and Productivity Shock Paradox

Sabin Ahmed
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Introduction

Objective:

- Extend the Villoria *et al.* Model to explore the local and global land use impact of a regional productivity (TFP) shock in oil palm production under different land regulations in:
  - Indonesia and Malaysia (IDN)
  - United States (USA)

- Explore how LOCAL and GLOBAL land use impacts differ when technological change occurs in a small developing country versus a larger developed economy.

Two experiments:

- (1) What happens to land use after a TFP shock under more restrictive land policy in IDN versus USA?

- (2) What happens to land use after a TFP shock under more relaxed land policy in the IDN versus the USA?

Experiment

Land policy regulation: Use changes in the regional Elasticity of Transformation parameter (ETRAE) for sluggish endowments (land) to mimic land policy restrictions and relaxation.

Experiment 1:

(1) Decrease ETRAE (magnitude) → Restrict mobility of land across different uses (forestry; crop land; pasture)

(a) Shock TFP in the oil palm sector in IDN by 39%;

(b) Shock TFP in the oil palm sector in USA by 39%;

Experiment 2:

(1) Increase ETRAE (magnitude) → Relax mobility of land across different uses (forestry; crop land; pasture)

(a) Shock TFP in the oil palm sector in IDN by 39%;

(b) Shock TFP in the oil palm sector in USA by 39%;

The Baseline (Villoria *et al.*, 2013)

Baseline results - TFP Shock in IDN			
aoall ("OSD", "IDN") = 39%			
ETRAE = -0.5 (baseline parameter value)			
IDN	Output (Δ%)	Exports (Δ%)	Forest land cover (Δ1,000 hec)
Domestic Changes	↑↑	↑↑↑	↓↓
Global Changes	→→→	N/A	↑↑↑

IDN Government decides to protect their forests → implements restrictions on land use.

Experiment 1: TFP Shocks under land use restriction

Baseline results - TFP Shock in IDN aoall (“OSD”, “IDN”) = 39% ETRAE = -0.5 (baseline parameter value)			
IDN	Output (Δ%)	Exports (Δ%)	Forests (Δ1,000 hec)
Domestic Changes	39	240	-118
Global Changes	0.1	N/A	499

Restrictive Policy & TFP Shock in IDN aoall (“OSD”, “IDN”) = 39% ETRAE = -0.1 (new parameter value)			
IDN	Output (Δ%)	Exports (Δ%)	Forests (Δ1,000 hec)
Domestic Changes	39	240	-40.9
Global Changes	0.1	N/A	340

Experiment 1: TFP Shocks under land use restriction

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IDN	Outputs	Exports	Forests (Δ1,000 hec)
Domestic Changes	39	240	-40.9
Global Changes	0.1	N/A	340

Negative spillover effect on other regions!

- IDN achieved the policy objectives without sacrificing economic activity.
- However, the world worse off due to the land regulation in IDN.

Question: Does IDN lose its forest because it's a small developing country-pair?

Hypothesis 1: Yes! Larger and developed economy expected to experience relatively less negative impact on forestry.

TFP Shock			
IDN	Outputs	Exports	Forests
Domesti[illegible]	[illegible]	[illegible]	-118
Glob[illegible]	[illegible]	[illegible]	499

Output grows more (48%) than TFP shock(39%)!

Restrictive Policy & TFP Shock			
IDN	Outputs	Exports	Forests
Domestic Changes	39	240	-40.9
Global Changes	0.1		340

TFP Shock in the US

aoall (“OSD”, “USA”) = 39%

ETRAE = -0.5 (baseline parameter value)

USA	Outputs	Exports	Forests
Domestic Changes	48	92	-400
Global Changes	-1		1323

Same result of TFP shock in the USA → Output and exports increase.

→ Greater deforestation in the US but world better off in terms of land preservation as US oil palm floods the world market and production of palm oil falls in ROW.

TFP Shock in IDN aoall (“OSD”, “IDN”) = 39% ETRAE = -0.5 (baseline parameter value)			
IDN	Outputs	Exports	Forests
Domestic Changes	39	240	-118
Global Changes	0.1		499

Negative large country effect on world output.

Domestic Changes	39	240	-40.9
Global Changes	0.1		340

TFP Shock in USA aoall (“OSD”, “USA”) = 39% ETRAE = -0.5 (baseline parameter value)			
USA	Outputs	Exports	Forests
Domestic Changes	48	92	-400
Global Changes	-1		1323

Productivity shock and increase in output in the US → US oil palm exports flooding the market → Global production of oil seeds decline by 1 %.

TFP Shock in IDN aoall ("OSD", "IDN") = 39% ETRAE = -0.5			
IDN	Outputs	Exports	Forests
Domestic Changes	39	240	-118
Global Changes	0.1		499

Restrictive Policy & TFP Shock in IDN aoall ("OSD", "IDN") = 39% ETRAE = -0.1			
IDN	Outputs	Exports	Forests
Domestic Changes	39	240	-40.9
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TFP Shock in USA aoall ("OSD", "USA") = 39% ETRAE = -0.5			
USA	Output	Exports	Forests
Domestic Changes	48	92	-400
Global Changes	-1		1323

Restrictive Policy & TFP Shock in IDN aoall ("OSD", "USA") = 39% ETRAE = -0.1			
USA	Output	Exports	Forests
Domestic Changes	48	92	-182
Global Changes	-0.7		1201

Question 2: Why do the two regions still loose their domestic forest?

TFP Shock to palm oil production in the US under more restrictive land policy not likely to be effective in preserving forest land because:

→ US export share of oil palm in world exports much larger (27%) compared to IDN (1.3%) and initial land transformation elasticity already pretty inelastic at -0.5%

What if we increase the elasticity of transformation of land as a proxy for relaxation of land preservation policy i.e. change ETRAE from -0.5 to -5?

TFP Shock in IDN			
IDN	Output	Exports	Forests
Domestic Changes	39	240	-118
Global Changes	0.1		499

Relaxed Policy & TFP Shock in IDN			
IDN	Output	Exports	Forests
Domestic Changes	39	240	-205
Global Changes	0.1		456

TFP Shock in US			
USA	Output	Exports	Forests
Domestic Changes	48	92	-400
Global Changes	-1		1323

Relaxed Policy & TFP Shock in US			
USA	Output	Exports	Forests
Domestic Changes	48	92	104
Global Changes	0.7		1525

Restrictive Land Policy

Marginal land allocation for oil palm	Before Policy	After Policy	Before Policy	After Policy
Local effects	Intensive	Intensive	Extensive	Extensive
IDN - TFP shocked	39.8	39.3	0.1	0.1
US - TFP shocked	39.5	39.5	1.5	1.5

IDN — Intensive ❯ Extensive

USA — Intensive ❯ Extensive

Relaxed Land Policy

Marginal land allocation for oil palm	Before Policy	After Policy	Before Policy	After Policy
Local effects	Intensive	Intensive	Extensive	Extensive
IDN - TFP shocked	40	39	0.1	0.1
US - TFP shocked	40	39	1.5	6.6

IDN — Intensive ❯ Extensive

USA — Intensive ❯ Extensive

Changes in Land Use

TFP Shock			
IDN	Forests	Cropland	Pasture
Domestic Changes	-118	68	50

Relaxed Policy & TFP Shock			
IDN	Forests	Cropland	Pasture
Domestic Changes	-205	127	773

TFP Shock			
USA	Forests	Cropland	Pasture
Domestic Changes	-400	141	259

Relaxed Policy & TFP Shock			
USA	Forests	Cropland	Pasture
Domestic Changes	104	242	-345

Changes in Price of Land

TFP Shock			
IDN	Forests	Cropland	Pasture
Domestic Changes	-2.7	-0.8	2.0

Relaxed Policy & TFP Shock			
IDN	Forests	OSD	Pasture
Domestic Changes	-1.1	-0.9	-0.3

TFP Shock			
USA	Forests	Cropland	Pasture
Domestic Changes	-0.8	7.1	0.3

Relaxed Policy & TFP Shock			
USA	Forests	Cropland	Pasture
Domestic Changes	-3.1	-7.5	-2.5

Climate change, food security and bioenergy policies

William Davis

Hoa Hoang

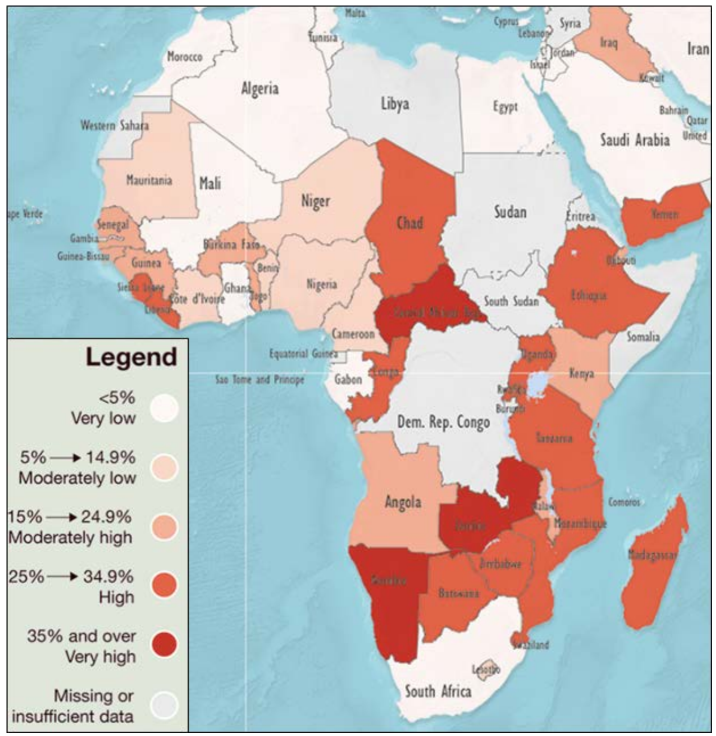
When Obama met Ban Ki-moon

…to discuss climate change.

Staff assignments ("quick and dirty" answers)

- William: What are impacts of increased emissions on Africa's ability to feed itself?
- Hoa: Impacts of US government's biofuel mandate on GHG emissions.

What are impacts of increased emissions on Africa's ability to feed itself?



Experiment

- Research question: What are impacts of increased emissions on Africa's ability to feed itself? (GTAP-AEZ includes emissions)
- How to approach?
  - Already have forecasts to 2021 > go beyond to add value
  - Update data (GDP (thru aoreg swap) & population – other variables too many interactions & what to swap?
- See predicted emissions from this model > feed through literature to get impacts on productivity
- Re-shock the result of 1st simulation using productivity shock resulting from emissions (can't incorporate as feedback directly in existing model)

Implementation

- Data update challenges: regions in download database don’t match GTAP – self-aggregate; ensure same base year for data for growth factor. Intensive!
- Results of 1st simulation problematic – caused reduction in factor uses (forced change through *aoreg* only)
- > Test with 1 country first before computing regional GDP for all - reduce to SSA 2004-7 update

Phase 2 – emissions impact

- ‘Emissions impact’ literature focuses on direct effect through carbon sequestration in soil
- > Search for climate change impact instead
- In fact, forecasts of productivity evolution available (Lobell & Gourdji, 2012)
- Worst case scenario – shock -2.272% to worldwide land productivity
  - Result: globally -0.6% in ag. Production by weight
  - SSA GDP ↓ crop production ↑ 0.2% relative to baseline

Results & interpretation

- Small increases in production across all land types except one relative to benchmark
- + $1.1b trade balance in ag. products
- Increased trade deficit in manufactures & services
- WHY? Difficult to explain – intensity of land use pre-shock does not predict post-shock trade patterns incl. ag. trade balance(despite HOS)
- Shock on SSA alone – ag. Production down
- Conclusion – more work needed!!!!

Impacts of US government's biofuel mandate on GHG emissions.

US biofuel mandate

Expectations

- ⬆ Biofuel mandate ->
- ⬆ Demand for corn (as the main input for biofuel production) ->
- ⬆ Corn price ->
- ⬆ Corn production ->
- ⬆ Cropland ->
- ⬆ GHG emissions (???)

Reality

- No biofuel sector -> assume biofuel is aggregated in chemical industry ("crp")
- No corn as a single commodity. In the model corn is aggregated in Coarse Grain ("gro") category -> Shock Coarse Grain sector as a whole.
- Assume that due to a change in technology, chemical industry demands for more coarse grains to increase its output.
- What to shock?

  -> First, forcing qo to be exogenous and technical change is adjusted accordingly.

  swap afall("gro","crp","USA")=qo("crp","USA")

Experiment 1: Increase coarse grain output -> price goes down -> need some increase on the demand side

Experiment 2: Increase chemical output -> VDFA("gro","crp","USA") turns negative.

Solution:

qo=+5%
to=+5%
pm=-2.76%
af(gro,cr)=-99.45%
STC(gro,crp,USA)
=0.00024

qo(crp,USA)

qva(crp,USA)

qf(gro,crp,USA)

+9261%

qfd(gro,crp,USA)

qfm(gro,crp,USA)

+9226%

+11596%

qds(gro,USA)

qo=+57%
pm=+25%

qo(gro,USA)

Land

Labor

Capital

...

AEZ1-AEZ18

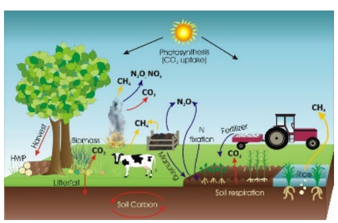
+2.43%

Pasture

-0.69%

Forest

-1.18%



GHG emission
+1 .4 bil tons
CO2-eq

Do we come to a consensus?

Border tax adjustment in the EU

Padma Swaminathan

Lau Tambjerg

Aim

- Large LUC emissions associated with palm oil
- WTO enables non-discriminatory tariffs to prevent carbon sinks
- Implementation of a border tax adjustment for CO_2 emissions from LUC outside of the EU
- What tariff rate should the EU implement?

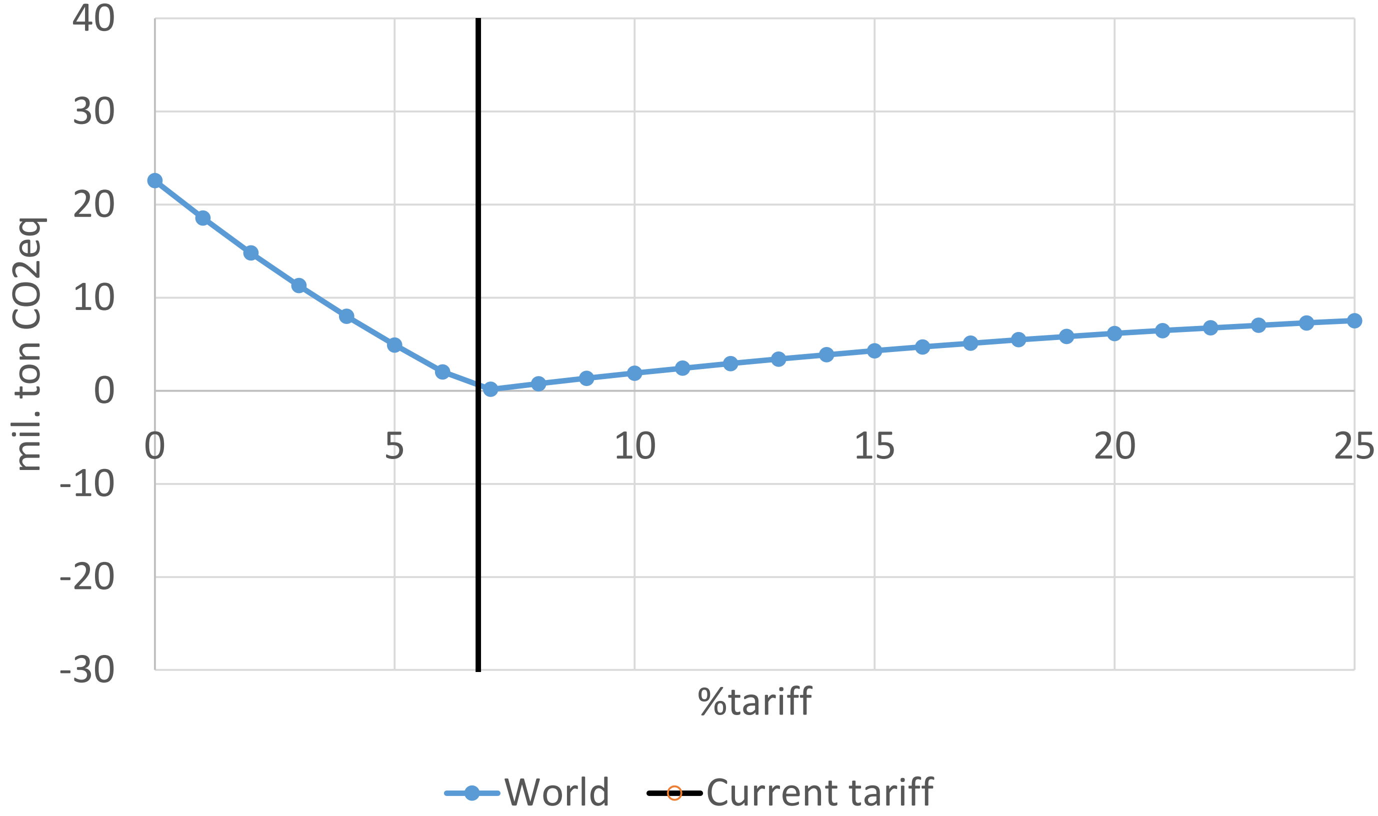
Tariff based on the EU-ETS

- Tax based on current price of CO_2 emission from the EU ETS
  - 9 USD/ton CO_2eq
  - Leading to a tariff of 13.9% on imports of vegetable oil from Indonesia/Malaysia to the EU27

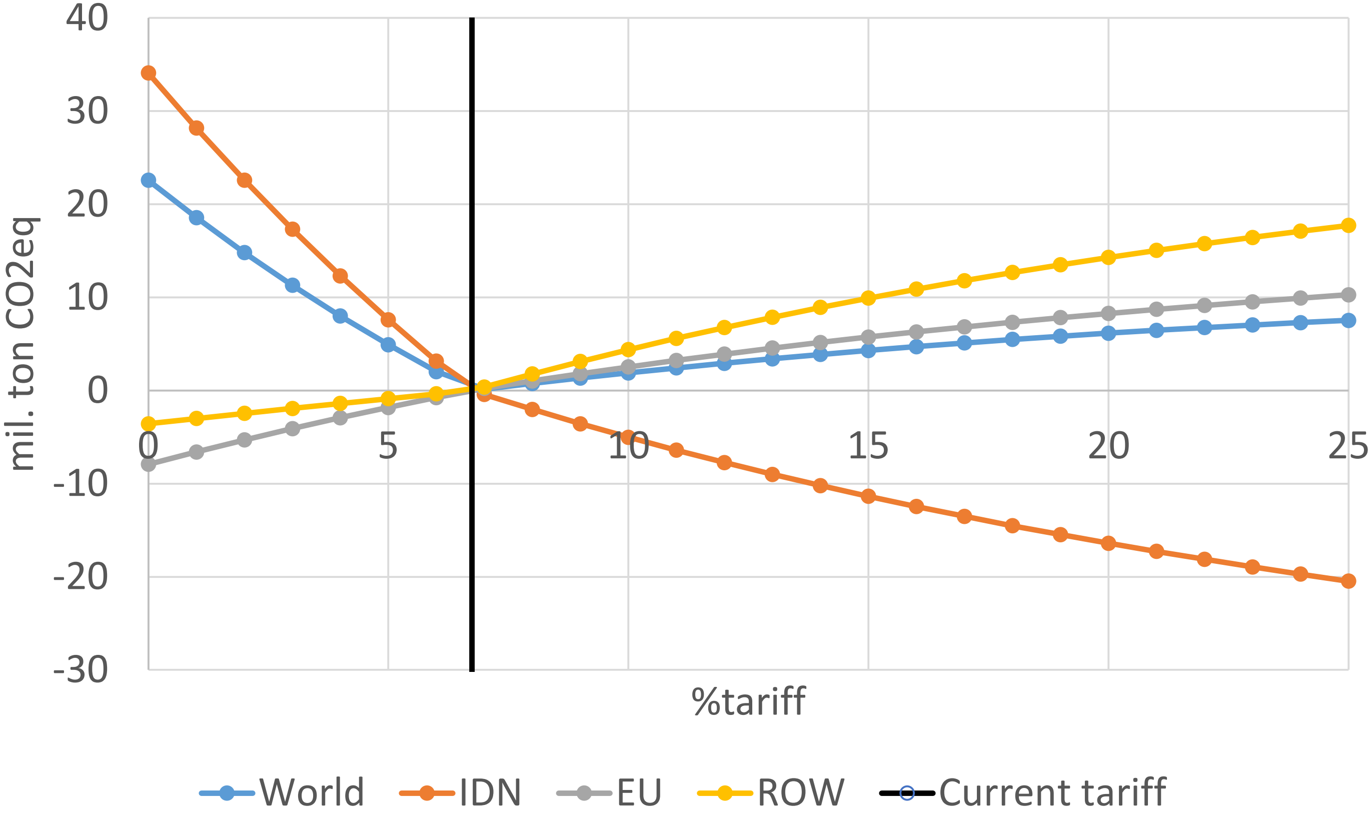
  - This tariff lead to increased world emissions: 3.8 mil. Ton CO_2eq
    - Indonesia/Malaysia emission reduction 10 mil. Ton CO_2eq
    - EU increased emission 5 mil. Ton CO_2eq

  - Which tariff can reduce emissions?
    - First, elimination of Import Tariff on VOL by EU27 (base data tms is 6%)
    - Then, progressively increasing Tariffs to about 25%

CO2 emissions and tariff increases



CO2 emissions and tariff increases



Elimination of Import Tariff
Output Expansion - Increased Import Demand

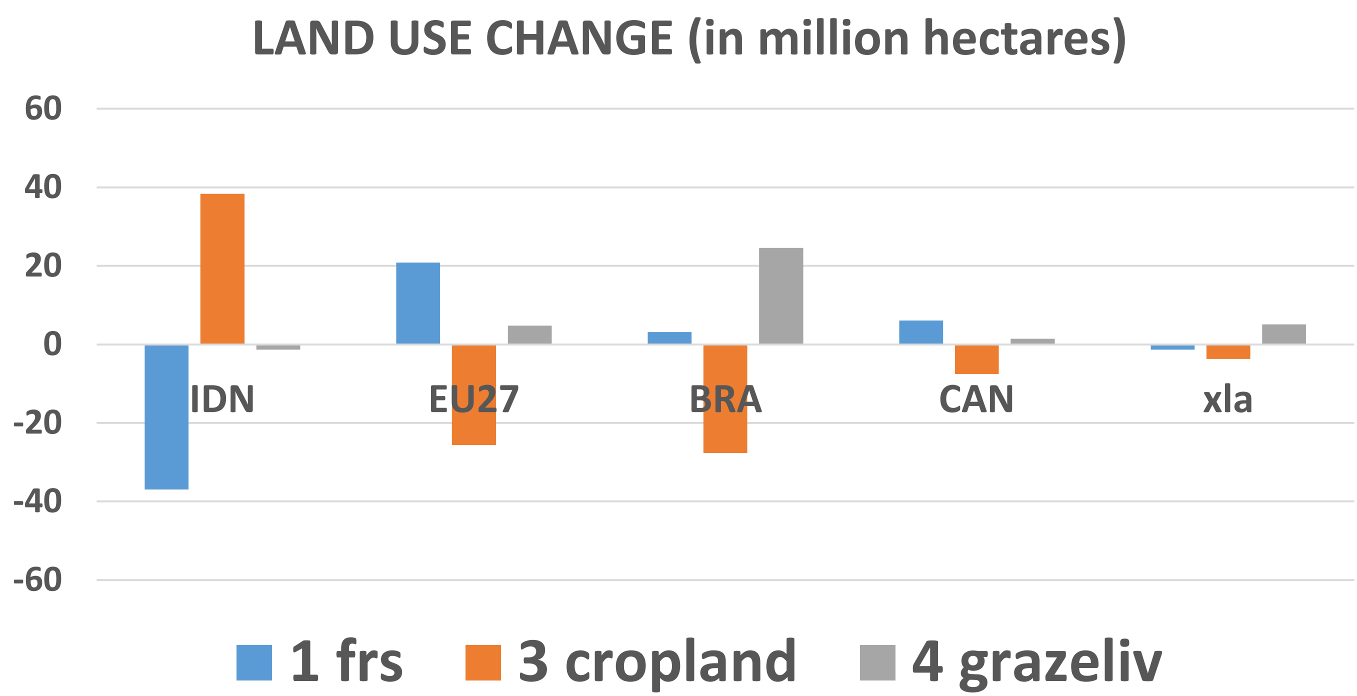
qo	1 BRA	2 CAN	4 EU27	5 IDN
32 vol	-0.38	0.14	-1.32	2.38
32 osd	-0.03	0	-0.04	0.37

qxs[*IDN*]	1 BRA	2 CAN	4 EU27	5 IDN
11 vol	-2.89	-2.73	44.58	0.57

Elimination of Import Tariff
Output Expansion - Increased Import Demand

- OSD increases by 0.37%
- Recall: Base Application is a TFP increase – Yield Increases due Intensive Margins & Extensive Margins Base Application is a Technology Shock.
- Extension - As import tariff is removed, most of the increase in OSD comes from forest land diversion about 37 m Ha
- Vs EU27, CAN, Brazil – forestry land use increases.

Elimination of Import Tariff
Land Use Change



Increase in tariffs (25%)

Impacts originate in different regions:

	Unit	Brazil	Canada	EU	Indonesia and Malaysia	Latin America
Emissions (total)	mil. Ton CO2eq	0.52	1.09	1.37	-2.72	0.011
Export change (vol)	mil. USD	101.5	0.8	344.4	-1148.8	119.3

Change due to substitution effect:

	Unit	Brazil	Canada	EU	Indonesia and Malaysia	Latin America
Expansion	% change	-1.71	-1.71	-1.71	-1.71	-1.71
Substitution	% change	6.61	6.98	6.5	-102	6.82

Increase in tariffs (25%)

Increase in exports of vegetable oils lead to an increase in required oil seed and output in this sector:

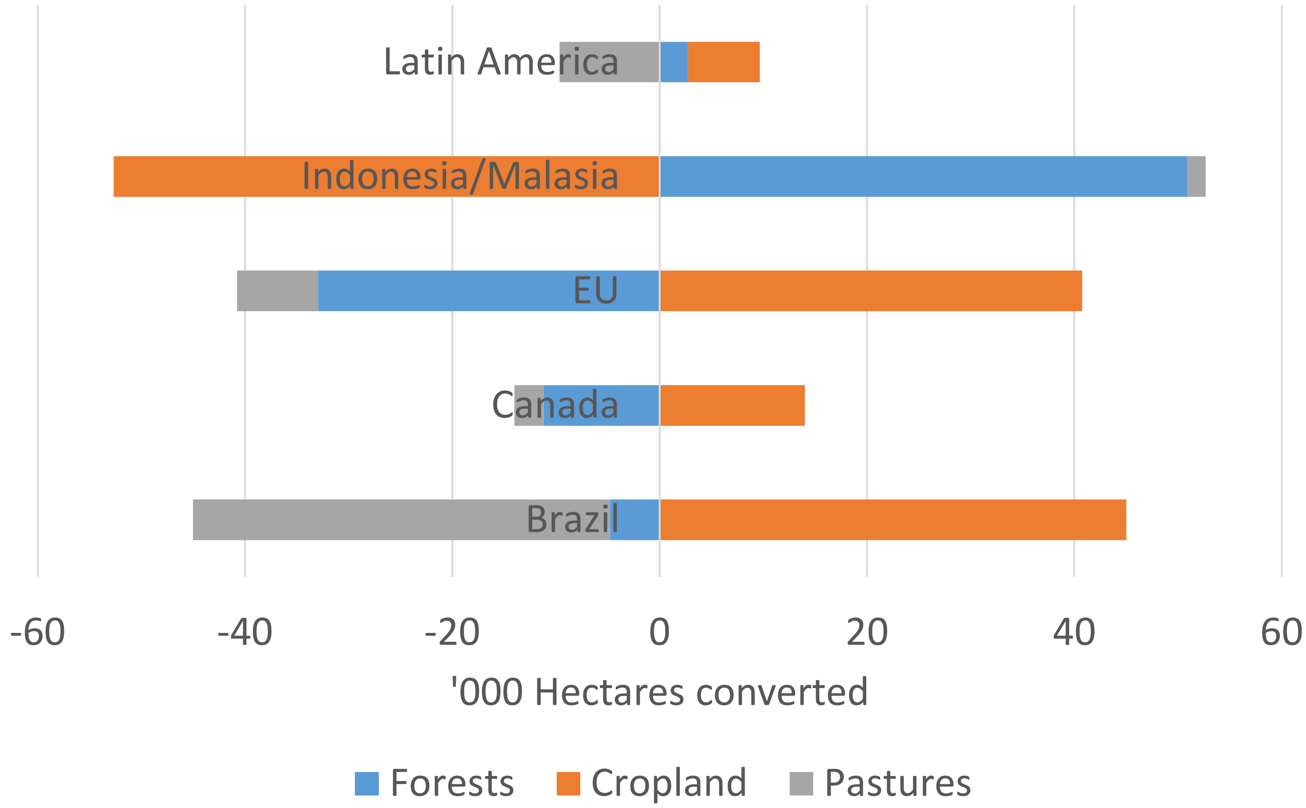
% change	Brazil	Canada	EU	Indonesia/ Malasia	Latin America
Oil seeds output	0.459	0.154	1.09	-1.94	0.229

Increase in conversion to oilseed:

'000 ha	Brazil	Canada	EU	Indonesia/ Malasia	Latin America
Oil seed conversion	87	11	135	-176	34
Other agriculture	-42	3	-94	123	-27
Total conversion to agriculture	45	14	41	-53	7

Increase in tariffs (25%)

Different conversion of land:



Conclusion

- Tariff around 7% lowest global emissions
- Important to consider response of other regions and market adjustments

- Parameters very important
  - Emissions from forest lost higher than forest gained