Land Use Modeling and Model Comparison

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An innovative **knowledge platform** that brings together five companies working with high synergy and a multidisciplinary approach, to address new agribusiness challenges using an integrated method.

The company has 14 partners and 43 senior and junior analysts, totaling 57 specialists.

**Plataforma Agro** assists agribusiness companies and organizations in solving complex issues and setting guidelines for the future.

- Competitive intelligence in agricultural markets
- Asset valuation and advisory services for investors
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- Risk assessment and mitigation in agribusiness sector
- Logistics infrastructure monitoring system
- Global agribusiness analysis
- Scenario and impact study development
- Sustainability and environmental regulation assessment tools
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- Content assembly and communication strategies
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- Strategic competition groups value maps
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- Trade-off research
- Land-use analysis and monitoring
- Crop mapping
- Decision support tools and certifications
- Identification of areas with agricultural potential and commercial interest
- Production assessment and monitoring
- Major event production and content development
- Agribusiness trends seminars
- Training and technical visits
- Custom speechwriting
Outline

- **Brazilian Land Use Model - BLUM**
  - Structure of the model and land use section;
  - Integrating economic and GIS database
    - Land use
    - Land use change

- **Comparison with GTAP-DEPS**
  - Structure
  - Results

- **Major findings**

- **Discussion**
The BLUM model: general information

- Partial equilibrium land use model developed for Brazil, but linked to FAPRI world model
- Joint partnership between ICONE and FAPRI-CARD (since 2007)
- “Spreadsheet” model (runs in Excel)

- BLUM model has been used in:
  - FAPRI US and world outlook
  - Regulatory Impact Analysis – RFS2
  - Brazilian Low Carbon Study (World Bank)
  - Brazilian Agribusiness Outlook 2022
  - (...).
Brazilian Land Use Model – BLUM

General Structure

Exogenous data
- Population;
- World and national GDP;
- World oil price and domestic gasoline price;
- Exchange rate;
- Inflation rate;
- Fertilizer price index;
- Vehicle fleet.

Source: ICONE

Exogenous variable

Endogenous variable
BLUM: Land Use Dynamic

Area Allocated to each Activity

Total Agricultural Expansion

Scale Elasticities

Share of each Activity

Activities Return

Own Elasticities

Competition Elasticities

Source: ICONE
BLUM: Interactions Among Sectors

Source: ICONE
Integrating economic and GIS database in BLUM
Biomes and BLUM regions

Amazon Forest
Atlantic Forest
Savannah
Steppe
Pantanal wetland
South Grassland

North Amazonia
Center West Cerrado
MAPITO and Bahia
Northeast coast
Southeast
South
Tropical Forest
Savannas
Savannas and Atlantic Forest
Atlantic Forest and Grasslands

Source: IBGE and ICONE.
Database in BLUM: Agronomical/physical constraints

Topography

Suitability (soil and climate)

Source: ESALQ, AgLUE-BR
Database in BLUM: Legal restrictions

- Brazilian Biomes and Legal Reserve (mandatory preservation rate)

Legal reserve 80%

Legal reserve 35%

Legal reserve 20%

Source: IBGE, MMA. Brazilian Biomes Map.
Total land used for agriculture and land with no impediments for agricultural expansion
Accumulated Deforestation (1,000 hectares)

Source: LAPIG/UFG, PRODES/INPE, SOS Mata Atlântica, MMA
Land use after deforestation
Amazon Biome

Monitoring from 2006 to 2008 by Land Use Classes (hectares)

Total area cleared monitored by the moratorium: 157,896 hectares

83,872 hectares (53%)
50,240 hectares (32%)
3,730 hectares (2%)
6,328 hectares (4%)
13,727 hectares (9%)

Pastures
Deforestation and burning
Crops
Vegetation recover
Other

Soybean moratorium project

Source: Abiove e Globalsat (www.abiove.com.br).
Deforestation in the Cerrado Biome (Brazilian savanna)

Polygons with deforestation characterized with agriculture or pasture (hectares, 2006/07)

Source: ICONE and LAPIG
Sugarcane expansion and LUC

South-Central Region: Classes of Land Use Converted to Sugarcane, 2007 and 2008 (1,000 ha)

Comparing BLUM and GTAP-DEPS
The GTAP-DEPS model is a multi-regional, global computable general equilibrium (CGE) economic model that incorporates cellulosic biofuels, dynamics and other enhancements to enable a robust simulation of the evolution and impacts of biofuel policy.

The prices of fossil fuels are determined endogenously allowing the model to capture the crucial effects of biofuel policies on energy markets, and its implications for the global economy.

It includes 18 world regions and 33 economic sectors, with one of these sectors representing the production of investment goods (Oladosu, 2012).

Land use within each region is based on agro-ecological zones (AEZ), which is an 18-category classification of the global land base using a combination of climate types (3) and length of growing period (6).

Mainly developed by Oak-Ridge National Laboratory (DOE)
Geographical comparison

Source: Oladosu et et, 2012
Major regional correspondence

- South: AEZ-12/AEZ-6
- Southeast: AEZ-5/AEZ-6/AEZ-4
- Northern Amazon: AEZ6/AEZ-5
- Center-West Cerrado: AEZ-5/AEZ-6

Source: Oladosu et al., 2012
In the GTAP-DEPS model, agricultural land demand for crop and livestock production are based on cost minimization by producers using nested constant elasticity of substitution functions.

Three stages
- In the first and second stages, total land in each AEZ is endogenously allocated among four land cover categories: forest, shrub/grass land, other land and agriculture (crops and pasture).
- In the third stage, agricultural land is allocated among crops (coarse grains, oilseeds, sugarcane, other grains, other agriculture), livestock (dairy, non-ruminants, cattle & ruminants), and forestry.

It is possible to compare land demand in GTAP-DEPS (first two steps) and BLUM land supply.

Source: Oladosu et et, 2012
Comparison: land supply parameters

Differences in magnitude
Elasticities tends to be lower when estimated with observed data (Nassar et al, 2012)
Correlation

Source: Oladosu et al, 2012
## Comparison of results for similar simulations

### Supply and demand variables of the sugarcane sector

Differences between base and shock scenarios ethanol sector in GTAP-DEPS and BLUM model

<table>
<thead>
<tr>
<th>Year</th>
<th>Model</th>
<th>Ethanol Prod (10^6 l)</th>
<th>Ethanol Consump (10^6 l)</th>
<th>Ethanol Exports (10^6 l)</th>
<th>Sugarcane crush (10^6 t)</th>
<th>Sugar production (1000 t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>GTAP-DEPS</td>
<td>969</td>
<td>-603</td>
<td>1,572</td>
<td>6</td>
<td>27</td>
</tr>
<tr>
<td>2011</td>
<td>BLUM</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2022</td>
<td>GTAP-DEPS</td>
<td>5,974</td>
<td>-3,294</td>
<td>9,268</td>
<td>41.5</td>
<td>-5,733</td>
</tr>
<tr>
<td>2022</td>
<td>BLUM</td>
<td>7,211</td>
<td>-2,059</td>
<td>9,268</td>
<td>81</td>
<td>-486</td>
</tr>
</tbody>
</table>

Source: Oladosu et et, 2012
Comparison of results for similar simulations

Comparison of land use results

The GTAP-DEPS result estimated a production expansion of 41.5 million tons of sugarcane and total agricultural land expansion of 48.95 thousand hectares. Assuming an average yield of 80 t/ha, we calculate that **1 ha of sugarcane expansion will reflect in 0.09 ha of total agricultural expansion**.

In BLUM, we found **0.17 ha** of agricultural expansion for each additional ha of sugarcane. This result is consistent with previous simulation of the BLUM model (19% Nassar et al., 2012).

- Although elasticities are lower in BLUM, we found higher leakage effect.
- All iLUC in BLUM is within Brazil.
Comparison of land use results (natural vegetation)

Following the same approach used by the US EPA for the RFS2, BLUM projects 37% expansion over savannas, 19% over grassland, 18% over forest and 17% over mixed vegetation.

GTAP-DEPS results indicate a much higher share of forest conversion in overall agricultural expansion (65% of total expansion), and almost all the additional expansion over shrubland and grassland (35% of total expansion).
Outline

Major findings
Major findings

- A first effort of comparison and collaboration between partial and general equilibrium economic based land use models.
- Parts of the model can be directly compared whereas significant structural differences remain in some areas of them.
- Land supply elasticities of BLUM and GTAP-DEPS were directly compared.
- We also identified (and quantified) the similarities of BLUM regions and the AEZs of GTAP-DEPS.
- The sugarcane and the ethanol demand structures are still quite different between the two models.
- It was also not possible to compare the land competition effect of the BLUM model with the land demand section of GTAP-DEPS.
- Specification of different sectors has more effect on final results than one single (although central) part of the model.

Is it possible that models borrow intelligence from other models?
Going beyond marginal improvements….

- PE and CGE; local and global models have years of developments (theory, database, testing…)

Is it possible that models transfer their intelligence to other models?

Some thoughts:

- Yes!
- Models must have different strengths, but also similar
- Linking models is one way
- Finding the correct feedback (both ways) is fundamental
- Identify knowledge gap, let the other model interfere in the solution
- Feedback must go in the right direction (caution)
- Convergence is facilitated if preceded with good database and structural forms alignment.
Thank You!
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