Impacts of the Biofuel Programs in Brazil on Water, Land-use and Climate Change: An Assessment with CLEW Approach

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CLEW Diagram
## Economic–Ecologic Commodity Flows

<table>
<thead>
<tr>
<th>Producing Sectors</th>
<th>Interindustry Transactions</th>
<th>Ecological Commodity Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agriculture</td>
<td>Mining</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Mining</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

### Ecological Commodity Inputs

- **Water**
  - Agriculture: 5
  - Mining: 4
  - Manufacturing: 0

- **Land**
  - Agriculture: 10
  - Mining: 0
  - Manufacturing: 0

Source: Miller & Blair (2009)
Domestic Energy Supply

Brazil
Source: BEN, 2010

Oil 38%
Natural gas 9%
Coal 5%
Uranium 1%
Renewable 47%

Hydroelectricity 15%
Biomass 10%
Sugarcane products 18%
Other renewable 4%

World
Source: REN21, 2010

Fossil fuels 78%
Renewables 19%
Nuclear 2.8%

Wind/solar/biomass/geothermal power generation 0.7%
Biofuels 0.6%
Biomass/solar/geothermal hot water/heating 1.4%
Hydropower 3.2%
Traditional biomass 13%
PROALCOOL

• Brazilian Program of Ethanol launched in 1975 to reduce the impacts of oil crisis in the national accounting and to create an alternative market for the sugar producers

• The PROALCOOL is the most successful program of commercial application of biomass for energy production and use in the world
Light Vehicles Production

Source: ANFAVEA
Areas of promising sugar cane expansion
Opportunities for Brazil in the Ethanol Market

- Conditions for mass-production of biofuels
- Oscillations in crude oil prices
- Growing environmental problems associated with fossil fuels
- The government is undertaking measures to keep the high share of renewable resources in the domestic energy supply
- Opportunity to export ethanol
Is Ethanol Production Sustainable in Brazil?

- CLEW approach
- Proposal
  - Energy model – LEAP
    - Luan dos Santos
  - Land use models – IPEA’s model and AEZ
    - Gustavo Malaguti
  - Water model – CROPWAT
    - Natália Fachinelli
  - Climate Model - Downscaling
    - Fernanda Tayt’Sohn
  - The integration – Input-Output Matrix
    - Eveline Vasquez
Initial Approach

- Domestic Demand of Ethanol
- International Demand of Brazilian Ethanol
  - Ethanol and Sugar Cane Prices
    - Land Requirement
      - Impact on Water Use
Sugarcane Production

Source: EPE
Chosen Areas to be Analyzed

- Paranaíba river basin located in the states of Goiás, Minas Gerais and Mato Grosso do Sul.
- These states represent 22% of the production and 18% of sugarcane land area.

Source: CANASAT, INPE
Domestic Demand for Ethanol

Source: EPE
Ethanol Exports

Source: EPE
Projected expansion of sugarcane production

• **~ 4 million ha** concentrated in Southeast (42%) and Center-West (Cerrado – 38%)

• **Two expanding areas where sugarcane production are planned to expand at least 1.59 million ha.** Besides, additional **5 million ha** are expected for the period 2010 to 2020, according to EPE’s studies.

Source: FIESP/ICONE, 2012

Source: PDE 2020
Sugarcane and Water Requirement

- The water requirement varies from 1500 to 2500 mm$^3$ per season, depending on the crop cycle, the phenological cycle, climate and other factors, such as available water in the soil.

Developing phases of sugarcane

Most critical phases of water déficit
Irrigation of Sugarcane in Brazil

• Differently from São Paulo and Northeast, the expanding areas analyzed in this study require irrigation.
Water footprint calculation

Database:
CLIMWAT 2.0 (FAO)

Estimations:
New_LocClim 1.10 (FAO)

Climate database:
- Tmin
- Tmax
- Wind speed
- Umidity
- Insolation

• Land database
• Crop calendar
• Productivity

Land database
Crop calendar
Productivity

Simulations of CROPWAT 8.0 (FAO)

• Evapotranspiration (Reference - Eto)
• Evapotranspiration (Crop - Eta)
• Irrigation demand

Water Footprint

• Literature
• CONAB
• MAPA

Outputs
Other Uses of Water

- Hydroelectricity: 76.7%
- Imports: 8.3%
- Biomass: 5.4%
- Wind: 0.2%
- Natural gas: 2.6%
- Coal: 1.3%
- Uranium: 2.6%
- Oil: 2.9%
- Natural gas: 2.6%
- Coal: 1.3%
- Uranium: 2.6%
Sectoral Water Demands

- Irrigation
- Livestock
- Mining
- Major Cities
- Ecosystems
- Domestic
- Commercial
- Industrial

Total Water Demand

Major Cities Water Demands

- Irrigation
- Livestock
- Mining
- Major Cities
- Ecosystems
- Domestic
- Commercial
- Industrial

Total Water Demand

Major Cities Water Demands
WEAP model
Next Steps

• Land use model
• Food security
• Impacts of climate change
• CGE model?
THANKS FOR YOUR ATTENTION!

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