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

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Major Features of the Brazilian Economy

GDP of US$ 1.573 billion
Population of 191 million
GDP/cap of US$ 8.218
Land Area of 8.5 million km$^2$

Source: IBGE, 2009
Domestic Energy Supply

Brazil
Source: BEN, 2010

World
Source: REN21, 2010

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

Hydroelectricity 15%
Biomass 10%
Sugar-cane products 18%
Other renewable 4%

Renewables 19%
Fossil fuels 78%

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%
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
    - José Feres (IPEA), Gustavo Malaguti
  - Water model – CROPWAT
    - Natália Fachinelli
  - Climate model – Downscaling
    - Fernanda Tayt’Sohn
  - The integration – CGE model (IMACLIM)
    - William Wills
Biofuels, Water and Food: Links and Feedbacks

Source: HLPE, 2013
Ethanol x Gasoline Production

Source: BEN 2012
Gasoline Imports and Exports

Source: BEN 2012
Sugarcane production, ethanol and sugar production and prices in Brazil

Source: HLPE, 2013
Initial Approach

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

Áreas sem necessidade de irrigação ⇒ 2,61 milhões de hectares;

Áreas com necessidade de irrigação suplementar de 80 mm ⇒ 9,38 milhões de hectares;

Áreas com necessidade de irrigação suplementar ou de salvamento de, no mínimo, 120 mm ⇒ 6,48 milhões de hectares.
**Methodology - Phases**

1. Choose the indicator of water use:
   - Water footprint
2. Simulate of the model CROPWAT
3. Calculate the water footprint with the CROPWAT outputs
4. Analyze the water pressure:
   - Analysis of water demand, availability and multiple use
Water footprint calculation

**Database:**
- CLIMWAT 2.0 (FAO)
- New_LocClim 1.10 (FAO)

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

**Land database**
- Crop calendar
- Productivity

**Simulations of CROPWAT 8.0 (FAO):**
- Evapotranspiration (Reference - Eto)
- Evapotranspiration (Crop - Eta)
- Irrigation demand

**Outputs:**
- Literature
- CONAB
- MAPA

**Water Footprint**
Preliminary Results

- Water Footprint (WFtot) - To grow the sugarcane biomass in Paranaíba river basin is 187 m³/ton, in average.

- The Blue Water Footprint (WF,proc,blue) – To irrigate the sugarcane in the best condition (avoiding water stress) in Paranaíba river basin is 48 m³/ton, in average.
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%
- 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
WEAP model
## Economic–Ecologic Commodity Flows

<table>
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<tr>
<th>Interindustry Transactions</th>
<th>Consuming Sectors</th>
<th>Final Demand</th>
<th>Total Output</th>
<th>Ecological Commodity Outputs</th>
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<td>Land</td>
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Source: Miller & Blair (2009)
Biofuel Impacts

CO2 Emissions (tCO2/10^6 R$)
Added value
Job creation (job/10^6 R$)
Land use (ha/10^6 R$)

-200
-100
0
100
200
300
400
500
600
700

CO2 Emissions

Added value

Job creation

Land use

2000
2005
Next Steps

- Analyze of water demand and availability of Paranaíba river basin, considering multiple use and irrigation requirement
- Propose the indicator of water pressure
- Sensitivity analysis: to run the CROPWAT with climate change scenarios
THANKS FOR YOUR ATTENTION!

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