Sustainable biofuels, rural development and private sector engagement: What can we learn from Brazil?

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Agenda

1. Overview on the current biofuel debate
2. Ethanol production in Brazil
   - Feasibility and sustainability (small vs large scale): COOPERBIO, RGS
3. The Brazilian biodiesel program
   - Feasibility and sustainability: Quixadá project
4. Discussions

Key issues in biofuel production

- Renewable energy
- Sustainability

Economic

Social

Environmental
Environmental sustainability

- New expansions create a carbon debt that must be repaid
  - Clearing of rainforests or savannas (cerrado)
- Induced land use change
  - Food crops must be replaced
- Sugarcane ethanol
  - Between 4 to 45 years to repay the carbon debt

<table>
<thead>
<tr>
<th>Biofuel</th>
<th>Former ecosystem</th>
<th>Location</th>
<th>Time to repay carbon debt (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm biodiesel</td>
<td>Tropical rainforest</td>
<td>Indonesia/</td>
<td>86</td>
</tr>
<tr>
<td>Palm biodiesel</td>
<td>Peatland rainforest</td>
<td>Malaysia</td>
<td>428</td>
</tr>
<tr>
<td>Soybean biodiesel</td>
<td>Tropical rainforest</td>
<td>Malaysia</td>
<td>319</td>
</tr>
<tr>
<td>Sugarcane ethanol</td>
<td>Cerrado wooded</td>
<td>Brazil</td>
<td>17</td>
</tr>
</tbody>
</table>

Economic sustainability

- Ethanol (2008)
  - Sugarcane: ~0.7$/gallon
  - Corn: ~3 $/gal
- Biodiesel
  - Soy: ~ 5 $/gal
  - Sunseed: ~ 7 $/gal
Social sustainability

• High commodity price
• This can have two opposite effects on poor/rural communities:
  1. Make them worse off
     • Excluded from the market
     • More expensive food and “food insecurity”
  2. Make them better off
     • Included in the “commodity” market
     • Producers and sellers
• How to make this link?

Research question

• Is it possible to have a model that is truly sustainable?
  – Focus on the social and economic sustainability
  – Biofuel as a rural development policy
Biofuels and the Brazilian experience

- Over 30 years experience with biofuels
  - Sugarcane ethanol is cost-competitive with gasoline
- Second largest producer of ethanol
- Large number of projects
- Innovative policies
  - Biodiesel program is promoting “socially responsible” biofuels
- Availability of different feedstock
  - Biodiesel
- Large number of small farmers (80%)
  - Interesting from a rural development perspective

Sugarcane ethanol

Hydrous ethanol
- ~93° GL
- Used pure in “flex-fuel” cars
- About 50% of the ethanol produced

Anhydrous ethanol
- >99,3° GL
- Mixed with gasoline
- 22% (law n. 8.723/93)
  - Mixture changes in relation to market price and volume (20% - 25%)
  - Today: 25%
Trends


Distillery data (Nov 2007 $)

<table>
<thead>
<tr>
<th></th>
<th>1979</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distillery type</td>
<td>Autonomous</td>
<td>Autonomous</td>
</tr>
<tr>
<td>Installed capacity</td>
<td>32,000 gal/day</td>
<td>260,000 gal/day</td>
</tr>
<tr>
<td>Investment cost</td>
<td>$ 28.5 M</td>
<td>$ 50 M</td>
</tr>
<tr>
<td>Unit investment cost</td>
<td>890 $/gal</td>
<td>200 $/gal</td>
</tr>
<tr>
<td>Plant efficiency</td>
<td>77%</td>
<td>98%</td>
</tr>
<tr>
<td>Sugarcane, production cost</td>
<td>3,100 $/Ha</td>
<td>1,314 $/Ha</td>
</tr>
<tr>
<td>Anhydrous ethanol, total cost</td>
<td>4.05 $/gal</td>
<td>&gt;1 $/gal</td>
</tr>
</tbody>
</table>
Trends

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Energy content (MJ/l)</th>
<th>Energy content in relation to oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anhydrous ethanol</td>
<td>21.27</td>
<td>55%</td>
</tr>
<tr>
<td>Hydrous ethanol</td>
<td>20.50</td>
<td>53%</td>
</tr>
<tr>
<td>Gasoline</td>
<td>32.00</td>
<td>83%</td>
</tr>
<tr>
<td>Crude oil</td>
<td>38.5</td>
<td>-</td>
</tr>
</tbody>
</table>

Scale of production

- 97%

- 1000 ha: 10 sq. km
Research question

- Is it possible to have a model that is truly sustainable?
  - Are smaller units more sustainable?
  - How smaller?

Economic

Social

Environmental

COOPERBIO, Palmeira das Missões, Rio Grande Do Sul
Socio-economic context

• Small farmers
  – 95.1% of farmers own less than 50 hectares of land

• Poverty
  – 90% of the families in the region live with less than 400 $/month
  – The region concentrates 36% of the poorest families in RGS

• One of the largest soy-producers of Brazil
  – 4.9% of landowners have 43.9% of the land
Why small scale ethanol?

- Transgenic soy
  - Highly risky for small farmers
  - Concentration of income
- Climate change
- High ethanol price
  - 2% produced in RGS
Baseline: soybean yield

Objectives of COOPERBIO

- Cooperative of small farmers
  - 23,000 small farmers in the region
- Pilot project
  - Diversify farmer’s production through small-scale ethanol unit;
  - Create a new logistical and distribution system for ethanol;
  - Integrate food and biofuel production.
- Project sponsor
  - Petrobras and Electrosul (about 2 M $)
Project outline

- **9 micro-distilleries**
  - Quality standards (?)

- **1 rectification units**
  - Reach ANP standards
  - Produce ethanol
    (1,200 l/day)

Micro-distilleries

- Eucalyptus
- Animal feed
Feedstock production

- Negotiated with Bank of Brazil specific credit conditions for farmers (PRONAF)
  - 500 $/Ha
    - 2% interest rate, 12 years
    - Seeds or seedlings
      - Semi-perennial trees (jatropha, tungue): vegetable oil
      - Native species: reforestation especially along water course
      - Energy crops: sugarcane and eucalyptus
      - Fruits: oranges and apple
  - Maximum of 2 Ha per family of sugarcane
    - Avoid monocultures
    - Product diversification
    - Share benefits among families
    - Borderline effect
### Feasibility analysis: assumptions

<table>
<thead>
<tr>
<th></th>
<th>Small-scale</th>
<th>Large-scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>New project (greenfield)</td>
<td>New project (greenfield)</td>
<td></td>
</tr>
<tr>
<td>Operated by 15 farmers</td>
<td>Centralized operator (i.e. investment fund) employing 2,400 workers</td>
<td></td>
</tr>
<tr>
<td>Manual harvesting</td>
<td>Some mechanization in harvesting.</td>
<td></td>
</tr>
<tr>
<td>The hydrous ethanol will reach the ANP standards</td>
<td>The hydrous ethanol will reach the ANP standards</td>
<td></td>
</tr>
<tr>
<td>Farmers sell sugarcane to the distillery at production cost</td>
<td>Distillery rents 70% of the land and purchases 30% of the feedstock at market price</td>
<td></td>
</tr>
<tr>
<td>All production costs keep constant with time, 12 years</td>
<td>All production costs keep constant with time, 12 years</td>
<td></td>
</tr>
<tr>
<td>Hydrous ethanol is sold to the final consumers</td>
<td>Hydrous ethanol is sold to a distributor</td>
<td></td>
</tr>
<tr>
<td>All sugarcane (29.5 hectares) is planted during the first year</td>
<td>All sugarcane (26,638) is planted during the first year</td>
<td></td>
</tr>
<tr>
<td>Fully operational already in year 1</td>
<td>Fully operational already from year 1</td>
<td></td>
</tr>
</tbody>
</table>

### Feasibility analysis: cash flow

<table>
<thead>
<tr>
<th></th>
<th>Small-scale</th>
<th>Large-scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed Capacity (l/day)</td>
<td>650</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Total investment – turn key (R$)</td>
<td>161,500</td>
<td>105,389,000</td>
</tr>
<tr>
<td>Unit investment (R$/l)</td>
<td>248</td>
<td>105</td>
</tr>
<tr>
<td>Total number of farmers or workers</td>
<td>15</td>
<td>2400</td>
</tr>
<tr>
<td>Investment per farmer (R$)</td>
<td>10,766</td>
<td>-</td>
</tr>
<tr>
<td>Interest rate (%)</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Loan period (years)</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Debt (%)</td>
<td>100</td>
<td>70</td>
</tr>
<tr>
<td>Depreciation (years)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Sugarcane production cost, year 1 (R$/Ha)</td>
<td>1,920</td>
<td>1,920</td>
</tr>
<tr>
<td>Sugarcane production cost, year 2-5 (R$/Ha)</td>
<td>470</td>
<td>470</td>
</tr>
<tr>
<td>Feedstock cost, average 5 years (R$/ton)</td>
<td>7.00</td>
<td>35 (30% purchased at 35 R$/ton)</td>
</tr>
<tr>
<td>Local price, hydrous ethanol RGS (R$/l)</td>
<td>1.89</td>
<td>-</td>
</tr>
<tr>
<td>Selling price, ethanol (R$/l)</td>
<td>1.50</td>
<td>0.75</td>
</tr>
</tbody>
</table>
### Feasibility analysis: technical input

<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area required (Ha)</td>
<td>30</td>
<td>25,862</td>
</tr>
<tr>
<td>Sugarcane yield (ton/ha)</td>
<td>66</td>
<td>87</td>
</tr>
<tr>
<td>Installed Capacity (l/day)</td>
<td>650</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Operating days/year</td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>Operating hours</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Production efficiency, milling (%)</td>
<td>75%</td>
<td>97%</td>
</tr>
</tbody>
</table>

### Results

- Small scale: more expensive
  - 0.73 R$/l equivalent to:
    - 96 $/barrel oil eq or
    - 2.11 $/gallon of gasoline

- Large scale: less expensive
  - 0.47 R$/l equivalent to:
    - 61 $/barrel oil eq or
    - 1.35 $/gallon of gasoline
Economic sustainability: payback

Social sustainability: income

Minimum salary: 415 R$/month
Sustainability: other factors

- Job created/$ invested
  - 1980’s: $23,000/direct job (nominal)
  - 1991: $41,000/job in 35 leading sectors
  - 2007
    - Large scale: $44,285/job created
    - Small scale: $27,726/job created (*)
- Job quality
- Number of jobs
  - 44,800 in the 5,600 municipalities (a new Petrobras)
- Food security
- Environmental impacts
  - New crops: displace food crop and induced Amazon or “cerrado” deforestation
- Roundtable on sustainable biofuels (labor rights, food security, poverty alleviation, land rights)

* Including subsidies

Key issues

- Commercialization
  - Auto-production and consumption
  - Niche market
    - New ANP resolution (through Petrobras) where microdistilleries up to 5,000 l/day can have own retailers
    - “Socially responsible ethanol” (certification or fair trade product)
    - Avoid “dumping” effect
  - Airplanes used in agriculture
- Quality standards (ANP)
  - Achievable if there will be a market
- Financing
  - Currently, too risky
  - New financing mechanisms there will be a niche
Job quality

- "Blitz in Alagoas gives freedom to over 550 workers in a sugarcane distillery"
  - "...terrible working conditions"
    - "several people living in one room"
    - "no windows"
    - "workers felt humiliated and treated like slaves"
  - "The auditor that was in charge of the operations said that it will be very difficult to export ethanol under these [working] conditions"

Conclusions

- Microdistilleries are viable and sustainable
  - The can occupy a portion (i.e. 5%) of the market share
- Several socio-economic benefits compared to large scale
- However their dissemination is fully dependent on the creation of a protected niche market
  - There are the conditions that this will happen
- Can some of these features be scaled-up to larger plants?
Biodiesel

- It is a renewable energy source that can be used for:
  - Transport (when blended with diesel – B5; B20; B100)
  - Energy generation

- It comes from the transesterification of vegetable oils or animal fats
  1. Seeds that have oil
  2. Press them to get the oil out
  3. Refinery: add methanol or ethanol + catalyst (NaOH)
    - Biodiesel
    - Glycerol
National Biodiesel Program (PNPB)

- Introduced in 2004
  - 2% blend by 2008; and
  - 5% blend by 2013
- Brazil imports ~9% of its diesel
  - About 3 Billion US$
- Keep leadership in biofuel
- Link poverty reduction to biofuel
  - President Lula’s social policy

The Social Fuel Certification

- Tax incentives to biodiesel producers that buy feedstock from small farmers
  - Small farmers and water scarcity

<table>
<thead>
<tr>
<th>Geographical region</th>
<th>Participation of family agriculture (%)</th>
<th>Participation of intensive agriculture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>10%</td>
<td>90%</td>
</tr>
<tr>
<td>Northeast and semi-arid</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Center-west</td>
<td>10%</td>
<td>90%</td>
</tr>
<tr>
<td>Southeast</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>South</td>
<td>30%</td>
<td>70%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>North region</th>
<th>Northeast and semi-arid region</th>
<th>Center-west</th>
<th>South East</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small farmers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Castor seed</td>
<td>100%</td>
<td>100%</td>
<td>30.50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm tree</td>
<td>100%</td>
<td>100%</td>
<td>30.50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any raw material</td>
<td>67.90%</td>
<td>67.90%</td>
<td>67.90%</td>
<td>67.90%</td>
<td>67.90%</td>
</tr>
</tbody>
</table>
Research question

- Is it possible to have a model that is truly sustainable?
  - Can an “energy production” policy help reducing poverty?

Quixadá biodiesel plant, Ceará
Quixadá biodiesel plant, Ceará

- Developed by Petrobras
  - Model for other 4 plants
- Capacity: 50 Million l/year
- About 45 M$
- Located in the semi-arid region of Brazil
  - Poorest
  - Potential for some oil seeds
    - Castor
    - Jatropha
    - Cotton
    - Palm

Project outline

1. Biodiesel plant

2. Extraction units

3. Feedstock supply (farmers)
Incentives to farmers

- Minimum price for the seeds
  - 0.35 to 0.5 $/kg
- Cash (75 $/Ha)
- Free seeds
- Technical assistance (EMATERCE and BNB)
- 50% of the cost for chemical stabilization of land
- BNB (regional development bank) helps in setting up the financial structure of the project

Project outline
Social benefits: assumptions

- Baseline: minimum salary (200 $/month)
- Production cost, any oilseed (300 $/Ha)
- Yield
  - Castor
  - Sunflower
  - Cotton
- Transport cost
- No pressing cost
- Price to producers: seeds
- Price to producers: oil
- Price to producers: cake/protein meal

Preliminary results

<table>
<thead>
<tr>
<th></th>
<th>A - Selling seeds</th>
<th>B - Selling oil</th>
<th>C - Selling meal</th>
<th>D - Selling oil and meal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With incentive</td>
<td>Without incentive</td>
<td>With incentives</td>
<td>Without incentives</td>
</tr>
<tr>
<td>Baseline (R$/Ha)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cotton (R$/Ha)</td>
<td>1.8</td>
<td>1.4</td>
<td>1.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Castor bean, NE (R$/Ha)</td>
<td>0.7</td>
<td>0.4</td>
<td>0.7</td>
<td>0.4</td>
</tr>
<tr>
<td>Castor bean, BRS En (R$/Ha)</td>
<td>1.7</td>
<td>1.3</td>
<td>1.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Sunflower (R$/Ha)</td>
<td>0.3</td>
<td>0.4</td>
<td>1.3</td>
<td>1</td>
</tr>
</tbody>
</table>
General considerations

- Still work on progress
  - Weekly changes
  - Why castor bean?
- Crop modifications may increase yield
- Conflict of interests between small farmers and biodiesel producers
  - The largest biodiesel producer did not pay what agreed with the farmers
    - Net losses of 20 M$ in 2007 (0.1 $/l)
- Smaller “local scale” units or larger “regional” ones?
  - Pressing units and biodiesel
  - Start from a “social” perspective

Micro-entrepreneurship
Final considerations

• It is possible to link poverty and rural development to the commodity market
  – Quiet a lot of work needs to be done
• Next steps
  – Ethanol
    • Understand the carbon balance
    • Can some of the features that characterize small scale plants be scaled up?
  – Biodiesel
    • Refine a business model that is viable at a local and national level
    • Work with the private sector to look at all the different components

Thanks