BIOENERGY
Environmental vulnerabilities and responses

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The context of bioenergy

From 6 to 9 billion by 2050 ...
Where the food production matters

Food (Direct) from Crops
Food crisis or food unbalances.....
CLIMATE VARIABILITY

RCCI, 20 Models, Three Scenarios (A1B, A2, B1)
Estimated Percentage Declines In Crop Output Due to Climate Change by 2080


Note: Carbon fertilization refers to the process by which higher concentrations of CO₂ can increase photosynthesis and reduce plant water loss, potentially offsetting the yield declines that are predicted due to climate change.
Volatility of prices
FOOD LOSSES UP 30% IN DEVELOPING COUNTRIES
HOW TO COPE WITH CLIMATE VARIABILITY AND FOOD LOSSES?
The last century brought increased agricultural efficiency.
Water stress potential index

Vigour map

Water stress map
DEVELOPMENT OF AGROINDUSTRY
Greenhouse gases emissions
Figure 15.3. CO₂ from Agriculture, Total and Per Capita, 2000

Top 25 GHG emitters

Sources & Notes: WRI, based on CAIT and IEA, 2004a. CO₂ emissions are from direct fossil fuel combustion only.
FARM GATE SOFTWARE FOR CALCULATION OF GHG EMISSIONS (specific for crops/soils and climate)

Rapporto Ismea (2010)
More land has been converted between 1950 and 1980 than between 1700 and 1850.

Agriculture is responsible for 25% of global land.
The global carbon cycle
2000-2008

CO₂ flux (PgC y⁻¹)

-8
-6
-4
-2
0
2
4
6
8

1850 1900 1950 2000

Other industrial emissions
Fossil fuel emissions
Deforestation
Atmospheric CO₂
Land
Ocean

2000-2008 (PgC y⁻¹)
7.7 (8.4)
1.4 (0.9)
3.0 (5 models)
2.3 (4 models)
0.3 Residual

Current Opinion in Environmental Sustainability
Global Forest Carbon Balance, 2000-2007

<table>
<thead>
<tr>
<th>Forest land</th>
<th>(Pg C yr(^{-1}))</th>
<th>LUC in tropics</th>
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</thead>
<tbody>
<tr>
<td>Biome</td>
<td></td>
<td>Land class</td>
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<tr>
<td>Boreal</td>
<td>0.5 ± 0.1</td>
<td>Deforestation emissions</td>
</tr>
<tr>
<td>Temperate</td>
<td>0.8 ± 0.1</td>
<td>1.7 ± 0.5</td>
</tr>
<tr>
<td>Tropical (intact)</td>
<td>1.0 ± 0.5</td>
<td>Regrowth (after LUC)</td>
</tr>
<tr>
<td>Total</td>
<td>2.3 ± 0.5</td>
<td>Total</td>
</tr>
</tbody>
</table>

Global net forest sink = 1.2 ± 0.9 (Net sinks in temperate and boreal zones)
IS THERE LAND ENOUGH?
130 t /ha of biomass in 18 months
BIOETHANOL PRODUCTION BY TAMARIX WOOD
STEAM EXPLOSION

Critical Flow equation:
\[ P_{\text{discharge}} \leq \left[ 0.80 \times (P_{\text{steam}} + 14.7) \right] - 14.7 \]
Delivers Sonic Velocity Steam Injection

Linear Actuator

Steam Inlet
“Full Pressure”

Modulating Steam Jet Diffuser

Inlet

Discharge

Clearance for fibrous materials and particles
Ethanol production as function of strains (Ruzzi et al. J.Biotech. 2011) RUZZI@UNITUS.IT

<table>
<thead>
<tr>
<th>Ceppo</th>
<th>Inoculo (OD$_{600}$)</th>
<th>Etanolo prodotto (g/L)</th>
<th>$Y_E$ (g etanolo /g glucosio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B0 123</td>
<td>0.5</td>
<td>41.73±0.22</td>
<td>0.42±0.01</td>
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<td>2.5</td>
<td>44.12</td>
<td>0.44</td>
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<td>5.0</td>
<td>45.19±0.62</td>
<td>0.45±0.01</td>
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<td>AN4/3</td>
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<td>48.12±3.37</td>
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<td>2.5</td>
<td>40.35</td>
<td>0.4</td>
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<tr>
<td></td>
<td>5.0</td>
<td>56.84±0.91</td>
<td>0.57</td>
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</table>

BO123 has recently genetically modified for pentose fermentation.
CONCLUSIONS

Bioenergy from crops can be sustainable if:

• Food crops are more resilient to cope with climate change (precision farming, breeding)
• Agro-industry reduce food losses and is able to feed urban population in developing countries
• Uncultivated land (i.e. desert areas) can be used with unconventional water resources (waste water)
• Second generation biofuels becomes operational