Water perspectives on large scale bioenergy

Water Related Synergies and Trade-Offs

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300 years of agricultural expansion

Year 1700
- 300-400 Mha cropland
- 400-500 Mha pastures

Present situation (roughly)
- ca 1600 Mha cropland
- ca 3200 Mha pastures

Source: Klein Goldewijk, RIVM, The Netherlands
Biomass consumption for energy (EJ/yr)

Place for energy crops?
Land availability for energy crops

One example: Image 2.2 modeling based on IPCC SRES

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Food trade</th>
<th>Technology development</th>
<th>Population 2100</th>
<th>GDP world 2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>maximal</td>
<td>high</td>
<td>7.1 Billion</td>
<td>86.2 Billion $95 y⁻¹</td>
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<tr>
<td>A2</td>
<td>low</td>
<td>low</td>
<td>15.1 Billion</td>
<td>17.9 Billion $95 y⁻¹</td>
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<tr>
<td>B1</td>
<td>high</td>
<td>high</td>
<td>7.1 Billion</td>
<td>53.9 Billion $95 y⁻¹</td>
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<tr>
<td>B2</td>
<td>very low</td>
<td>low</td>
<td>10.4 Billion</td>
<td>27.7 Billion $95 y⁻¹</td>
</tr>
</tbody>
</table>

Possibly available for energy crops:

- Abandoned cropland
- Low-prod. land not used for agriculture
- “Rest land”, excluding forest areas, agricultural land,...
Land availability for energy crops

A1: 2020
Land availability for energy crops

A1: 2030
Land availability for energy crops

A1: 2040
Land availability for energy crops

Energy crops on abandoned cropland: roughly 400 EJ/year
Water use for bioenergy

Evapotranspiration (km³ yr⁻¹)

0 2000 4000 6000 8000

2000 2050 2100

Year

Estimated average evapotranspiration from global cropland

Source: Berndes (2002)
Global Environmental Change 12: 253-271
ET from food and bioenergy, 2005 and 2050 (km³/year)

Water use for bioenergy

A scenario of future water use and availability

• “Best guess” scenario of the future state of global water systems (WaterGAP 1.0 model)

• Modified to include water demands from an expanding bioenergy sector (IIASA-WEC, A3 scenario)

• Two alternative modifications:
  - additional water withdrawal
  - reduction in water availability
Water use for bioenergy

A scenario of future water use and availability

• “Best guess” scenario of the future state of global water systems (WaterGAP 1.0 model)
• Modified to include water demands from an expanding bioenergy sector (IIASA-WEC, A3 scenario)
• Analysis based on two frequently used indicators:
  - water barrier concept
  - use-to-resource ratio
Water use for bioenergy

![Diagram showing water stress indicator](slide-image)

Withdrawal (m³/cap/yr) vs. Availability (m³/cap/yr) for various countries. The graph illustrates the water stress indicator with a scale ranging from absolute scarcity to no stress.

Global & regional bioenergy potentials

Present food crop harvest (indicative)

- Surplus forest growth
- Agricultural and forestry wastes and residues
- Dedicated woody bioenergy crops on surplus agricultural land
Role of bioenergy in strategies to...

- Increase productive use of blue/green water flows
- Improve water productivity in agriculture

- $R = 100\%$
- $T = 15-30\%$
- $E = 30-50\%$
- $R_{off} = 10-25\%$
- $D = 10-30\%$
Water Related Synergies and Trade-Offs

Pastures = 25 x sugarcane area
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- Biomass production cost - Value of environmental service (€/MWh)

- Average production cost for Sweden

- C price 20€/tC. Termination of plantation after 25 years.

- C price 100€/tC. Re-establishment of plantation after 25 years.

Area (1000 ha)
Water Related Synergies and Trade-Offs

• The technical bioenergy potential is large
  • Agricultural development is essential for realizing the potential and bioenergy demand may stimulate this development
  • There are clear water related synergies but also challenging trade-offs that need to be managed
  • An industry capable of converting new types of energy crops (and residues) to biofuels is well positioned to drive a positive development
Water Related Synergies and Trade-Offs

• The BIG trade-off
  • Incremental damages due to bioenergy today versus uncertain climate related risks tomorrow
    • Bioenergy induced ecosystem conversion today vs. Large-scale ecosystem breakdown tomorrow
    • Near term food security impacts of bioenergy vs. Future famines due to climate induced disasters
  • Low stabilization targets may not be feasible without large scale bioenergy
Thank you!