Issues and Assumptions Relevant to Biomass Modeling

Gregg, Jay Sterling; Bolwig, Simon

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Jay S. Gregg
Simon Bolwig
Importance of Biomass in a modeling framework

If bioenergy isn’t considered, it gives an incomplete picture of the potential for other energy resources, technologies, climate and environmental impacts, and socio-economic and sustainability assessments.
Approaches to Modeling Biomass

• **Top Down**: Maximize economic value of land, Benefit-Cost, or long term utility under a given carbon constraint

  *Versus*

• **Bottom Up**: Obtain detailed information on technologies, costs and options for a given piece of land and then determine the carbon prices at which the various options become economic

• **Integrated**: a dynamic land allocation system is built into the model and calculates land distribution and economic land use endogenously (IMAGE, GCAM)

  *Versus*

• **Soft Linked**: Land distribution/ Land use scenarios/ Biomass production are derived exogenously and input into the IA model (Most IA models)
Bioenergy Potential

- **Theoretical Potential** – total amount that can theoretically produced from climate zone, soil, PET, etc.

- **Technical Potential (Supply Potential)** – often used interchangeably with theoretical, but here taken to mean the amount that can feasibly be produced given current land use and technology.

- **Economic Potential (Demand Potential)** – amount of biomass demanded by the global market in consideration of other energy options.

- **Sustainable Potential** – amount of biomass that can be produced given considerations for socioeconomic and environmental sustainability.
Bioenergy Potential

Theoretical

Technical

Economic

Sustainable
Considerations for Biomass Supply (Potential isn’t everything!)

- **Productivity and bioenergy**
  - Types of land availability
  - Yield assumptions
  - Technology

- **Socioeconomics and bioenergy**
  - GDP growth assumptions
  - Future diets and meat consumption
    - Allocation of capital and labor between agriculture and industry

- **Sustainability and bioenergy**
  - Protected lands
  - Forests
  - Biodiversity
  - Food security
  - Water
  - Socioeconomic sustainability and livelihood impacts

- **International trade and bioenergy**
  - Full global trade in bio resources
  - Partial trade on sustainability/energy security requirements
  - Effect of trade on regional economies and environments
Example 1 Environmental Impact: Modeling Future Global Diet in GCAM

- GCAM: Global Change Assessment Model- endogenous land use model
- Changes based on land rent (equal marginal profit between potential uses), subject to share weight, and production cost
- Also includes collection and aggregation cost for residue biomass, carbon cost from land conversion

\[
S_i = \left( \alpha_i \pi_i \right)^\sigma \sum_j \left( \alpha_j \pi_j \right)^\sigma
\]

Source: Clarke and Edmonds (1993), McFadden (1974)

Change in land shares when land type 1’s profit increases by 20%
Diet Scenarios

a) Meta-regression projection from historical FAO data
b) Diets converge to that of India & Africa
c) Diets in the developing world evolve to diets in the developed world
d) Diets evolve to western diet (US, Canada, Western EU, Australia/NZ)

Gregg, Hvid (in Review)
Economic Bioenergy Potential

- Potential decreases as meat consumption increases

Gregg, Hvid (in Review)
Land Use Impact: Allocation
Substantial differences in land allocation

Gregg, Hvid (in Review)
Land Use Impact: Managed vs. Natural Land
Large differences in farm/plantation land across scenarios and regions.

Gregg, Hvid (in Review)
Example 2 Socioeconomic Sustainability
Integrating livelihood and equity outcomes into global assessments of bioenergy deployment
Biofuel deployment affects livelihoods via global and local processes

Assessment of livelihood outcomes for smallholder oil palm producers in Indonesia (Obidzinski et al 2012)

Source: Creutzig et al 2013
Possible livelihood outcomes from bioenergy deployment

Normal text: aspects considered by 'best' IAMs (Golub et al 2012)
Red text: Outcomes not considered by IAMs

<table>
<thead>
<tr>
<th>Livelihood aspect</th>
<th>Benefits</th>
<th>Harms</th>
</tr>
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<tbody>
<tr>
<td>Income and occupation</td>
<td>Higher total income</td>
<td>Lower purchasing power of non-farm poor</td>
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<td></td>
<td>Multiplier effects on wider economy</td>
<td>Lower income of displaced people</td>
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<tr>
<td></td>
<td></td>
<td>Exclusion of non-monetary occupations</td>
</tr>
<tr>
<td>Food</td>
<td>Higher security with higher income</td>
<td>Lower food access for non-farm poor</td>
</tr>
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<td></td>
<td>Reduced food supply from subsistence farming</td>
</tr>
<tr>
<td>Land</td>
<td>Higher land rent for formal land owners</td>
<td>Lower access to land and ecosystem services, particularly for those without land titles</td>
</tr>
<tr>
<td>Other assets</td>
<td>New education, health and production infrastructure</td>
<td>Detrimental health impacts</td>
</tr>
<tr>
<td></td>
<td>Higher savings</td>
<td>Social conflicts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indebtedness</td>
</tr>
</tbody>
</table>

Source: Creutzig et al 2013
Conclusions

• **Summary:**

• **Place-specific factors** (production model, land tenure, initial land use), and **national contexts**, strongly influence livelihood effects of bioenergy deployment

• There is a likely **tension between aggregate and equity impacts** of bioenergy deployment that goes unnoticed by IAMs

• Bioenergy pathways and production models should not only produce positive aggregate outcomes, but also **respect and improve place-specific livelihoods**

• **Implications for global IAMs:**

• IAMs **do not consider**
  
  • **distribution** of costs and benefits at micro scale – e.g. by not considering livelihood assets
  
  • **factors** shaping the interaction between bioenergy and livelihoods – production model, land tenure, ...

• IAMs **could be improved by**

  • introducing **distributional parameters** – e.g. %age of affected households with improved or reduced income, food access, land tenure and health as a result of deployment schemes
  
  • **Soft-coupling** IAMs with local livelihood analyses and CGE/sector models – e.g. ranking deployment scenarios in terms of their impact on livelihood dimensions (income, food, assets) based on **mapping of such impacts using livelihood assessment figures** such as Fig. 2.

  Risø DTU, Danmarks Tekniske Universitet
Biomass in TIAM
Biomass is treated as a fixed resource, similar to something mined or extracted. Thus the cost curve is the only “lever” available for creating different bioenergy assumptions and scenario.

*Technically, in TIAM, the price per unit energy remains constant (though it can be changed), and the supply varies through time.
Biomass in TIAM

Global Biomass Potential in TIAM

- Biomass Liquids
- Landfill Gas
- Industrial Waste
- Municipal Waste
- High price solid biomass
- Medium price Solid Biomass
- Low price Solid Biomass
- Energy Crops
Options for Development of TIAM wrt Bioenergy

1. Continue to use other models and meta-analyses to soft-link supply potentials into TIAM

2. Develop TIAM to handle land allocation and land use endogenously.
   - Better understanding of the potential for various feed stocks (i.e. crop choice)
   - Better understanding of the potential for various technologies (agricultural management, harvesting, aggregating, transporting, processing, and distributing)
   - Estimates of trade, and the geographical areas where changes would most likely occur.
   - Better understanding of the impacts (LUC, emissions, biodiversity, food prices) from bioenergy
   - More robust integrated model of the energy system