Bioenergy, Land-Use Change and Food Security

Vantage Point: Views on Food, Fuel and Land Use

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Acknowledgements: Gbadebo ('Debo) Oladosu, Paul Leiby, Nagendra Singh, Virginia Dale

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Roadmap for Talk

• Issues
  – Reliance on oil
  – Food security
  – Deforestation
  – Estimating effects of bioenergy
  – Science and models

• Solutions
Roadmap for Talk

• Issues
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• Common solutions
The U.S. pays dearly in a non-competitive market

- Wealth transfer*
- Long-run GDP losses*
- Disruption costs*
- Military costs
- Foreign policy costs
- Strategic stockpile costs
- Other indirect costs

*Economic costs estimated with the ORNL oil security metrics model

Cartelized, volatile market produces large direct costs to the U.S. economy: up to US$ 500 billion in 2008

Oil imports also:
1. Exacerbate trade deficits
2. Erode US$
3. Transfer wealth to unfriendly regimes

Steps to reduce costs of oil dependence:

- Reduce demand for transportation fuels
  - Fuel economy
  - More flex-fuel, electric-hybrid vehicles

- Diversify sources and accelerate development and use of efficient substitutes for oil *
  - Expand domestic fuel production
  - Reduce industrial and home heating use

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*Bioenergy markets can help (saving billions per year at the pump)

Du and Hayes, 2011 (CARD, Iowa State University)
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Food security

- Rising prices, volatility
- Consumers and producers suffer
- Nearly a billion undernourished (FAO)

As long as people are hungry, this issue is not going away!

Volatility in agricultural markets seems to have increased

Extreme price movements of agricultural commodities pose a threat to world food security

Policy measures should improve market functioning and increase countries’ resilience to shocks

Governance issues

- Global supply exceeds requirements
- Distribution, losses, infrastructure, inefficient markets
- All countries in protracted crisis show high levels of food insecurity
- Policy and governance failures contribute to market failures, hunger, poverty


Undernourishment statistics are a product of definitions, methods, models and available data.
## Bioenergy and food security

Global Sustainable Bioenergy Project “GSB”

Rather than a threat, could bioenergy be part of the solution?

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solutions</th>
</tr>
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<tbody>
<tr>
<td>Food Insecurity</td>
<td>Alleviate Poverty</td>
</tr>
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<td>• All wealthy people have access to food</td>
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<tr>
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<td>• All hungry people are poor</td>
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**Food and Fuel**

Developing nation perspective: grow things we can eat AND sell!

“...bioenergy is not only compatible with food production; it can also greatly benefit agriculture in Africa…”

- Dr. Rocio A. Diaz-Chavez, Imperial College, London.

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**Problem**

Food Insecurity

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**Solutions**

Alleviate Poverty

- All wealthy people have access to food
- All involuntarily hungry people are poor

Education

- Agricultural practices
- General

Sustainable & efficient resource use

- Land, soil, water

Biofuels - done right*

- Rural employment
- Rural markets
- Land management Experience

* See: Kline et al. 2009 “In defense of biofuels, done right”

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Steps to improve food security

1. Improve rural livelihoods *
   ✓ Agriculture
   ✓ Market access
   ✓ Timely information

2. Reduce risk
   ✓ Social safety net
   ✓ Transform food aid
   ✓ Economic resilience
     • Diversify markets *
     • Expand bases of production *

3. Improve analysis, monitoring (early warning)

4. Improve institutional capacity, policies, market functions

5. Reduce volatility*

*Bioenergy markets can help

Sources: Oxfam 2010; FAO 2009 a and b, FAO 2010 a and b.
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- Common solutions
Deforestation drops, 2005-2010
(FAO Forest Resource Assessment 2010 - Global)

- Global tropical deforestation rate (avg. annual loss) fell > 20% compared to prior decade, led by decline in Brazil (chart below)

![Graph showing deforestation rates](chart.png)

**Deforestation rate in Brazil’s Amazon, thousands square km per year**

Yellow bar for 2010 indicates preliminary result of analysis.
Global deforestation rate drops 2000-2010 (FAO Forest Resource Assessment 2010)

- Amazon deforestation versus U.S. liquid biofuel output
- Correlation is not causation (need analysis, models, validation)

U.S. Biofuel Production (thousands US gallons per year) Source: Renewable Fuels Association

Threats to forests: governance issues (policy, corruption, poverty, insecurity), fire and pests...

Solutions:
- Rural livelihoods*
- Land tenure
- Inventory & protect key conservation areas*
- Improved governance, local participation and capacity, enforcement
- Land-use plans, soil management, productive uses to reduce fire*

*Bioenergy markets can help

Source: Kline, 2008 California Biomass Collaborative., based on USAID-FAA Sec. 118/119 Reports for 2000-2008. FAO 2010c and forest management and conservation best practices: http://www.fao.org/bestpractices/content/05/05_02_en.htm
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Land cover, land use:

- **Constantly changing**
  - Cropland shifting → becomes fallow → to grassland, eventually → secondary forest → and partially returns to crops...
  - Lines between classes blur, overlap
  - Use / Cover: distinct, different values

- **Difficult to measure**
  - Data aggregated and homogenized
  - Data at different temporal and spatial scales differ greatly, inconsistent

- **Small adjustments in data (available land; assumed carbon stocks) have huge effects on modeling results***

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Global LUC emissions revised down, still “guesstimates”

- 90% of current CO2 emissions are from fossil fuel; fossil share rapidly rising

Global data uncertainty: large cropland differences (forest data worse; grassland horrid)

Source: Preliminary results, Johannes Feddema, Geography Department, University of Kansas
Estimates of Global Cropland circa 2000 can vary by over 100% within Agro-Ecological Zones (AEZ)

Global cropland totals range from 11.6 million Km² (MODIS) to 17.4 million Km² (Hurtt), or by +/- 580 million hectares.

Chart prepared by Nagendra Singh, ORNL 2011.
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• Solutions?
Observed LUC is complex, dynamic process

- **Driving first-time conversion:**
  - Limited capacity for governance, policies
  - Extractive (incl. oil/gas) industries
  - Access, biophysical conditions
  - Making/holding land claims
  - Poverty - this is the safety net

- **Major land assets and drivers are omitted from the global economic models used to estimate LUC**

Most remaining forests are public lands: clearing is (a) illegal or (b) policy-driven. Global economic models omit these, other key factors.

Source: Agrawal et al., 2008, Science 320
Example: GTAP Model (Tyner et al. 2010)

Tyner et al., 2010: Figure 1. An overview of the GTAP model
Land use models - constrained by data, filters

Initial Change Drivers
(cultural, technical, biophysical, political, economic, demographic)

Initial Land-Use Change

Ongoing Land-Use Changes

Land cover
(typically measured by remote sensing methods at one place and time)

Global Economic Models

Demand

Prices, Quantities, and Distribution of Goods

Carbon Stocks

Key Filter: LC, carbon, change data

Filters: private land, rents

Filters: LC data, scale, sources

Subsequent Change Drivers

Approximately 4 times > cropland use
Maintained with fire

Source: CBES 2010
http://www.ornl.gov/sci/besd/cbes/
LUC estimates, compared to what?

- Land available for crop expansion without deforestation (previously cleared, underutilized) = 500 to 5000 million hectares\(^{(1)}\)

\(^{(1)}\) Enormous range due to pasture, grassland, marginal land estimates
LUC estimates, compared to what?

- Land available for crop expansion without deforestation (previously cleared, underutilized) = 500 to 5000 million hectares\(^{(1)}\)
  Circle size assumes 1500

- Global land area impacts: [million hectares per year]
  - Fire = 330-430 \(^{(2)}\)  
  - Dev./Urban exp. \(^{(1)}\) = 1.5  
  - LUC bioenergy est. \(^{(3)}\) = 0.2 (too small to illustrate)

\(^{(1)}\) Enormous range due to pasture, grassland, marginal land estimates

Sources: \(^{(1)}\) Kline et al. 2009; calc. by author based on FAO 2007.  
\(^{(2)}\) Giglio et al. 2010.  \(^{(3)}\) Tyner et al. 2010 (3 m ha total/14 years)
Science and Models

Science follows a *systematic methodology based on evidence*.*

Models are simplified views of the world, not true representations of complexity.

Models explore specific relationships

– E.g. “shock” prescribed system to estimate biofuel effects on land
– Results reflect assumptions, baseline, input data, conceptual view
– **Science (data + time) needed to assess and verify**

There is no scientific consensus on methods or estimates of indirect land use change from bioenergy**

Don’t forget to look outside!

What LUC is most important?
Farmland, change, drivers ≠ cropland, change, drivers.

US farmland avg. loss 1999-2007: 3.4 M acres per year (USDA NASS 2010).

NRI states that “developed” land class grew 27 M acres 1992-07 as cropland fell by 24 M acres same period (USDA 2009)
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• What are solutions?
# Win–Win options

Good policy and governance are key

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<th>Improve livelihoods, resilience</th>
<th>Build capacity</th>
<th>Reduce volatility</th>
</tr>
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<tr>
<td>Provide incentives (for things we can measure)</td>
<td>Start with what is most important</td>
<td>Cooperate (plenty we can agree on)</td>
</tr>
</tbody>
</table>

Increase system efficiency and system capacity to provide multiple services over long term
Cropland can be net sink (or source) of carbon, with potential to increase C storage

Common Solutions for food and fuel

| Improve soil management | • Tillage intensity  
| • Crop mix, rotations, cover crops  
| • Land restoration  
| • Technology (plants, microbes, biochar) |
| Increase Efficiency | • Open, transparent markets  
| • Minimize transaction costs  
| • Prioritize, incentivize, measure  
| • Reduce inputs, increase yields |
| Diversify | • Uses and markets  
| • Substitution options  
| • Bases of production |
| Adopt Systems Perspective | • Multi-scale  
| • Long-term, adaptive  
| • Integrated land-use plans |
Thank you!

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- Additional information:
  - Resources
  - References
  - One-slide summary
Some Information Resources

- DOE Biomass and Biofuels Program: [www.eere.energy.gov/biomass/](http://www.eere.energy.gov/biomass/)


- DOE Office of Science, Bioenergy Research Centers: [http://genomicsgtl.energy.gov/centers/](http://genomicsgtl.energy.gov/centers/)

- Alternative Fuels Data Center - [http://www.eere.energy.gov/afdc/fuels/ethanol.html](http://www.eere.energy.gov/afdc/fuels/ethanol.html)


- Biomass R&D Initiative: [www.biomass.govtools.us](http://www.biomass.govtools.us)

- EERE INFO CENTER: [http://www1.eere.energy.gov/informationcenter/](http://www1.eere.energy.gov/informationcenter/)
References

- EC 2010. The impact of Land Use Change on Greenhouse Gas Emissions from Biofuels and Bioliquids - Literature review. July 2010 (in-house review conducted for DG Energy as part of the European Commission's analytical work on indirect land use change)
- Feddema, Johnannes. University of Kansas (KU), Geography Dept. faculty home page (accessed January 24, 2011). http://www2.ku.edu/~geography/peoplepages/Feddema_J.shtml#research
References (pg 2)


- Gilbert C. L. 2010a. How to understand high food prices. J. Agric. Econ. 61, 398–425


References (pg 3)


References (pg 4)


Additional Slide: Summary of Key Points
Summary of key points:

- Dependence on imported oil brings high costs
- Global market prices reflect supply/demand issues:
  - Supply constrained by monopolies, weather, policies
  - Demand driven by emerging economies’ and excess liquidity
- Failures of policy, markets and governance underlie food insecurity, deforestation, and poverty
- LC/LU/LCC data are uncertain; models reflect assumptions
  - Analysis of empirical data offers different LUC perspectives
  - Changing world requires adaptive approaches
- Effects of bioenergy on food, forests, climate... can be positive or negative
- Win-win solutions (security + food + fuel + forests + climate + livelihoods...) are possible and needed now
Global LUC emissions are still “guesstimates”

About 90% of current CO2 emissions are from fossil fuel; fossil share rapidly rising. These comparisons ignore terrestrial sink (graph below).

Global land sink estimate varies each year with weather, but typically offsets LUC emissions by factor of about three.