Evaluating Agricultural Water Use with Crop Life Cycle Assessments

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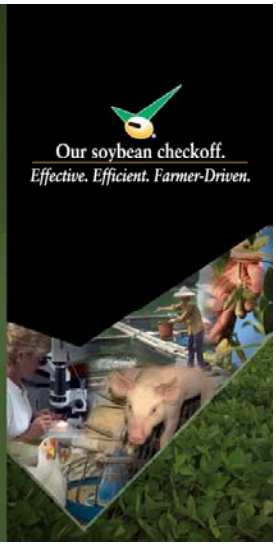
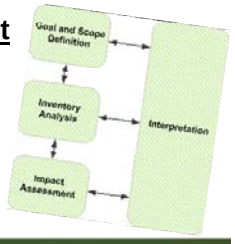


Life Cycle Assessment

Life cycle assessment (LCA) is the evaluation of all environmental impacts and social damages attributable to all phases of the existence of a product, including its production and processing.

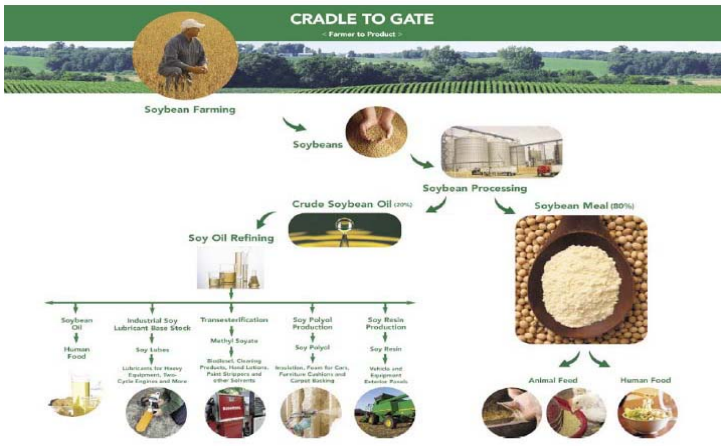
Phases of Life Cycle Assessment

1. Goal and Scope
2. Life Cycle Inventory
3. Life Cycle Assessment
4. Interpretation



Scope Variations

- **Cradle-to-Grave**
  - A full life cycle assessment from production of raw materials or manufacture of the product through disposal of the product
- **Cradle-to-Gate**
  - A partial life cycle assessment from production of raw materials or manufacture to the factory gate.
- **Cradle-to-Cradle**
  - A specific cradle-to-grave assessment where the end of life of the original product is a recycling process.
- **Gate-to-Gate**
  - A partial life cycle assessment that only looks at one value-added process in the entire production chain.



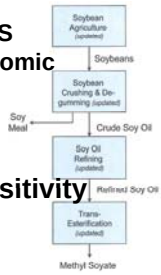
Challenges Encountered in Modeling

- **Overall system boundaries**
  - Is water used in production of upstream inputs considered?
  - Co-product impacts
  - Additional resource utilization by non-ag elements
  - Difficulty in obtaining high quality data
- **Scale of data considered**
  - National average vs. local average?
  - Time scale: snapshot in time vs. weighted average?

Can address by modifying system boundaries or adjusting allocation models.

Unit Processes Studied and Boundaries

- Conducted as a Cradle-to-Gate analysis for each
- ISO 14044 guidelines to set boundaries
  - Classified into impact categories using BEES
  - (BEES)Building for Environmental and Economic Sustainability
- Functional unit of 1,000 kg of product
- Mass allocation for baseline analysis
- Economic allocation used to assess sensitivity



ISO 14044 Data Quality Considerations

- ***Representativeness***: temporal, geographical and technological considerations
- ***Consistency***: method uniformity over analysis components
- ***Reproducibility***: qualitative assessment of extent methodology and data allows independent result verification
- ***Precision***: variability of data values in each category
- ***Completeness***: percentage of the flow measured
- ***Data sources and information uncertainty***

Representativeness of Soybean Data

Unit Process	Temporal Coverage	Technological Coverage	Data Type	Georgaphical Coverage	Data Source
Soybean Agriculture	2000's	Industry average	Secondary data	U.S. production	Various
Soybean Processing	Mid 2000's some 2007	Industry average	Primary data	U.S. production	NOPA
Soybean Oil Refining	2000's	Industry average	Secondary data	U.S. production	Various
Biodiesel Production	2008	Industry average	Primary data	U.S. production	NBB

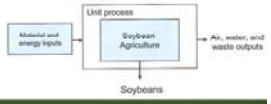
Limitations and Uncertainty of Data

- ***General Use Limitations***
  The data are subject to a margin of error due to data quality differences and data unavailability
- ***Product Performance***
  It is beyond the scope of this study to evaluate each product for multiple precise applications. Interchangeability of products is difficult to determine.
- ***Uncertainty***
  Secondary data may cover a broad range of technologies, time periods and geography. Because hundreds of datasets are linked together and degree of deviation from specific system being studied is unknown.

Agricultural Water Use Considerations

How is water use being measured by the LCA?

- Consumptive use of irrigation water
- Calculated eutrophication potential based on 50 water effluents
  - Effluents associated with use of nitrogen, phosphorus and potassium fertilizers
  - Water effluents associated with pesticide use



Consumptive Use of Irrigation Water in Soybean Production

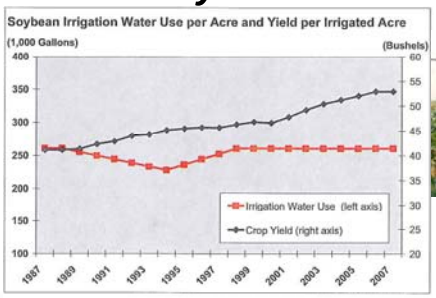


Figure 5.6. Soybean Irrigation Water Use Indicator

Soybean Irrigation Water Calculations

7,044,546 irr. Acres x 0.7 acre-ft (228,000 gal.) = 1.606 million gal.
1.606 million gallons/2,582,423,697 bu. = 622 gallons/bu

Year	Total soybean acres harvested	Total yield, bu	Irrigated acres	Bu/acre (irrigated)	% acres irrigated	Water applied (acre-ft)
1997†	67,773,274	2,560,330,804		37.8		
2002†	72,399,844	2,707,719,216	5,480,192	37.4	7.5	
2003‡			5,346,276	(48)	7.4	0.8
2007†	63,915,821	2,582,423,697	5,237,075	40.4	8.2	
2008‡			7,044,546	(49)	11.0	0.7

†2007 Census of Agriculture, U.S. Summary and State Data, Vol. 1. Geographic Area Series, Part 51 (USDA, Feb. 2009)

‡2007 Census of Agriculture, Farm & Ranch Irrigation Survey (2008) Vol. 3, Special Studies, Part 1 (USDA, Nov. 2009)

Irrigation Data Limitations

- Differences in irrigation water source ignored.
- Data from USDA-NASS Census of Agriculture, 2007

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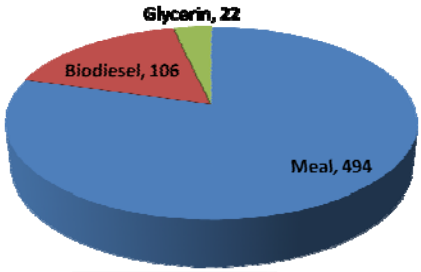
Allocation of Irrigation Water (gal.) over Soybean Co-Products (Biodiesel)



One bushel of soybeans produce 1.4 gal. biodiesel
106 gal. water/1.4 gal. biodiesel = 76 gal. water/gal. biodiesel

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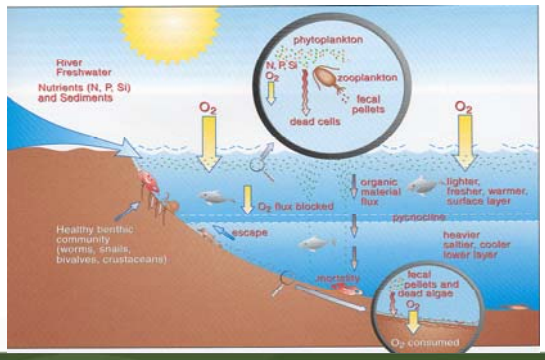
Estuary Hypoxia



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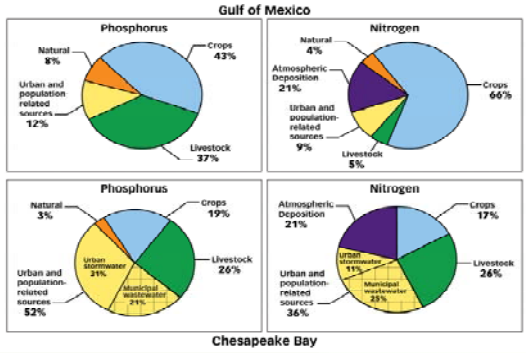
Sources of Eutrophication



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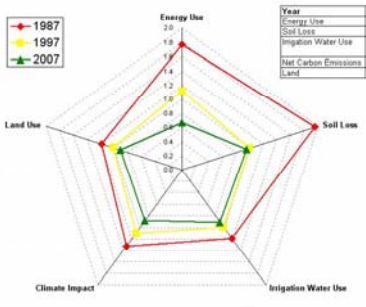
Soybean Environmental Production Efficiency Evaluation – Keystone Alliance

Soybean Efficiency Indicators (Per Unit of Output, Index 2000 = 1)



Year	2000	Unit
Energy Use	0.044	Million Btu/bushel
Soil Loss	101.0	Pounds soil/bushel
Irrigation Water Use	19.4	Thousand gallons/incremental bushel due to irrigation
Net Carbon Emissions	2.2	Pounds Carbon/bushel
Land	0.026	Acres/bushel

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Key Consequences and Challenges to Using LCA for Evaluation of Agricultural Water Use and Policy Decisions

1. No real standard for LCAs
2. Poor data quality or no data
3. Modeling decisions affect the results
1. LCA most useful in evaluating full product lifecycle

Can be best used to determine where key resource drags occur.

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