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ASI Food Carbon Footprint Initiative

Ultimate Goal:
Reduce greenhouse gas emissions in the food system; promote actions towards a “low-carbon diet”.

Program Objectives:
- Research – using a “life cycle assessment” framework
- Outreach about findings
- Ag professionals, industry, policymaker, consumers
The Food System

- A significant contributor to climate change
  - 30% of global warming potential
- An opportunity for reducing carbon emissions
How do GHG impacts arise in the food system?

- Contributions throughout the supply chain
GHG Emissions in the Supply Chain

- **Agricultural production**
  - 50% of food-related GHGs
  - Fossil fuel generated CO2 – machinery, irrigation (pumping), pesticides, fertilizers
  - Methane (CH4) - livestock production
  - Nitrous oxide (N2O) – soils, manure, fertilizers
  - Changing land use
Processed Foods
Retail Outlet
Consumption
Greenhouse Gas Emissions in the Food System

Carbon dioxide (linked to fossil fuel use)
- Fertilizer production
- Agric fuel use
- Processing
- Food preparation
- Refrigeration

Methane (x25)
- Rice production
- Livestock metabolism

Nitrous oxide (x310)
- Fertilizer application
- Livestock manure
ASI Food Carbon Footprint Initiative

Unpack the food supply chain

Uncertainties due to complex tradeoffs
The best food you can eat may be in your own backyard. Here is one man’s quest for the perfect apple.

By John Cloud
Life Cycle Assessment

Sample Life Cycle Inventory for Tomato Paste

- Production
  - Planting
  - Culture
  - Irrigation
  - Pesticides
  - Fertilizer
  - Equipment Maintenance

- Transport

- Processing

- Wholesaler

- Transport

- Retailer/Food Service
System Life Cycle

- LCA is an *accounting* system to describe and quantify environmental sustainability indicators and metrics

**Diagram Description:**

- **M, E** material and energy inputs for process and distribution
- **W** waste (gaseous, liquid, solid) output from product, process and distribution
- **T** transportation between stages
- **→** material flow of product components
Life Cycle Inventory Analysis (LCI)

- Quantify inputs and outputs for a given product system throughout its life cycle.

Life cycle inventory:

- Primary Materials
- Recycled Materials
- Primary Energy

System Evaluated:

- Products
- Co-Products
- Air Pollutants
- Water Effluents
- Solid Waste

Adapted from G. Keoleian’s Industrial Ecology Course Slide, University of Michigan, 2007
Research Framework: Five Key Questions

- Embody typical dilemmas and tradeoffs facing consumers
- Distill key issues that span across the food supply chain
- Prioritize where to focus research and policy attention
- Identify “hotspots” in the supply chain
Key Question #1

Tradeoffs Between Type of Production System and Transport Distance

Sample question from a consumer’s perspective:

*Is it better to buy organic vegetables that are imported from out of state or conventionally-grown vegetables sourced locally?*
Key Question #1: Production System vs Transport

Organic systems often have lower energy, GHGs than conventional systems, primarily due to fertilizers.

- How do yields compare?
- How far can you transport before savings evaporate?
Key Questions #2

Scale of the Food System

How do:

small-scale local food systems, involving small farms, short distribution distances, direct marketing

compare to

regional-scale food systems, involving regional distribution networks

compare to

global-scale food systems involving global distribution networks?
Key Question #2: Scale of the Food System

Network for Transport and Energy
Key Question #3

Seasonality of Production, Processing, and Transport

Sample question from a consumer’s perspective:

*In winter, is it better to buy domestic canned tomato paste that has undergone a lot of processing, or to cook with fresh tomatoes shipped from overseas?*
Key Question #3: Seasonality, Processing and Transport

Total Life Cycle Energy Use
Fluid Milk: 4,574.35 BTU
Dried Milk: 3,862.40 BTU

Whittlesey and Lee, 1976, WSU
Key Question #3: Seasonality, Processing and Transport

- **Heated greenhouses**: use 9 to 21 times more energy than open air production (Van Hauwermeiren et al. 2007)

- **Tomatoes consumed in Sweden**:
  - Fresh, from S Europe: 5.4 MJ/kg
  - Canned, from S Europe: 14 MJ/kg
  - Greenhouse, Sweden: 66 MJ/kg  
    (Carlsson-Kanyama et al. 2003)
Key Question #4

Livestock Production Systems

How do different protein products compare to one another (eggs versus chicken, milk versus beef, etc.) and how do livestock products compare to plant-derived protein foods?
Key Question #4: Livestock

- Meat and dairy products: **half** of all food-related emissions in EU study
- Animal-based protein foods are 2-100 times more energy-intensive than plant-based protein foods.

![Contribution of food groups to Dutch GHG emissions kg/CO2eq](chart)

Key Question #4: Livestock

Trade-offs: Range-fed versus Feedlot

- GHG production

Concentrated feed

- Methane
- Nitrous oxide
+ Carbon dioxide

Photo: Penn State Dairy and Animal Science Dept.
Key Question #5

Pre-Retail versus Post-Retail Life Stages

How large are consumer-level energy and climate impacts compared to all the pre-retail sectors of the food system?
Key Question #5: Post-Retail

Netherlands study: Consumption accounts for \( \frac{1}{4} \) of GHG emissions of the Dutch food supply chain (Kramer 2000)

Kitchen Appliances:
Changing from electricity to gas and using more efficient appliances could reduce energy and GHG by 6% in total system.

Consumer Transportation Cooking Method
Six Major “Hot Spots”

- Livestock-related methane and nitrous oxide emissions
- Synthetic nitrogen fertilizers
- Air freight
- Heated greenhouse production
- Post-retail, consumer transport and food storage
- Food waste at multiple points in food chain
Life Cycle Assessment: ASI Progress to Date

- 3 products chosen for LCA:
  - Processing tomatoes
  - Rice
  - Dairy
- Literature reviews completed
Rice LCA:
Evaluate and compare energy/GHGs resulting from...

- Organic vs. Conventional Production Systems
  - Trade-offs between GHGs in pesticide, fertilizers in conventional systems vs. field management practices in organic systems

- Straw management practices
  - Trade-offs between CO$_2$ emissions from burning vs. methane emissions from incorporation
What we already know about Rice

- Grain farming ~ 80% of total carbon emissions within US agriculture (crops)
  - Primary emissions: N20 (N fertilizer), CH4 (flooding fields-anaerobic bacteria)
  - Plant growth absorbs CO2-offsets some CH4
- Organic farming reduces N20 (denitrifying bacteria), but may increase CH4
- Power generation, supply – source of GHGs
  - Alternative energy sources can reduce
Life Cycle Assessment: ASI Progress to Date

- Rice LCI underway [Life cycle inventory]
  - Process map: seed to retail (defines system boundaries, models system)
  - Gathering input data:
    - energy data, land use, water - (production)
    - processing data
    - drying and storage data
    - transportation data
Straw Mgmt
Incorporate into soil or burn

Land Preparation
Levee maintenance, Leveling, Tillage, Fertilizer application

Planting & Growing
Aerial rice seeding, herbicide, fertilizer, insecticide, fungicide applications

Harvest
Combine rice, bankout

Transport, Drying, Milling, Storage
Transport to dryer, Dry Mill Warehouse

\[ \text{CO}_2 \text{ from straw burning & fuel use} \]

\[ \text{CO}_2 \text{ from fuel use} \]

\[ \text{CH}_4 \text{ from flooded soil (straw & cover crops – organic)} \]

\[ \text{N}_2\text{O from fertilizer} \]

\[ \text{CO}_2 \text{ from fuel use} \]

\[ \text{CO}_2 \text{ from fuel use} \]
Life Cycle Assessment: ASI Next Steps

- LCI outputs calculated; evaluated by:
  - GWP (g CO2e)
  - Ozone depletion (ug CFC-11 eq.)
  - Acidification (g SO2 eq.)
  - Eutrophication (gPO4 eq.)

- Create tools to help growers, industry reduce GHGs at various stages
Reducing Food Carbon Footprints

- Technological, managerial options
  - Anaerobic digestion, solar, wind power
  - Manure, legumes for fertilizer
  - Mixed crop-livestock farming (nutr recycling)
  - Organic
  - Soil carbon sequestration

Source: Garnett, Food Climate Research Network (FCRN), Univ of Surrey, 2008
Reducing Food Carbon Footprints

- Technological, managerial options
  - Efficient refrigeration (home use)
  - Shift to sea, rail, local sourcing
  - Energy metering at retail level, labeling, waste reduction strategies

Source: Garnett, Food Climate Research Network (FCRN), Univ of Surrey, 2008
Reducing Food Carbon Footprints

Changes in Consumption

• Eat fewer meat and dairy products
• Eat less (esp foods w low nutr value)
• Eat seasonally, locally
• Prepare food for several meals
• Avoid food waste; compost
• Cook and store in energy-conserving ways
• *Consume less, overall*

Source: Garnett, Food Climate Research Network (FCRN), Univ of Surrey, 2008
Integrate with Other Aspects of Food System Sustainability

- **Environmental**
  - Energy & Climate Change
  - Water use, Biodiversity, Land use, Soil health

- **Social**
  - Development, Animal welfare, Equity

- **Economic**
  - Food security, Nutrition
For more information.....

- Agricultural Sustainability Institute:
  www.asi.ucdavis.edu