Energy Demand and Environmental Impact of Food Systems

Carlo A. Amadei
HEJC
March 7th 2019

FOOD SYSTEM IMPACT

IMPACT = Population * Quantity * Intensity

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ENERGY = Population * Food * En/unit of food

FOOD SYSTEM IMPACT

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ENERGY = Population * Food * En/unit of food

GHG = Population * Food * GHG/unit of food

FOOD SYSTEM IMPACT

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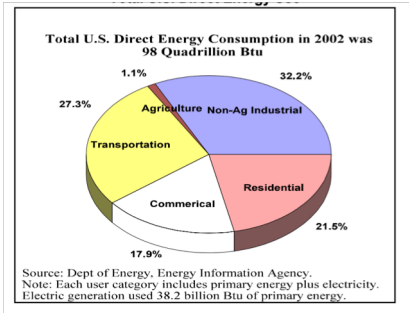
ENERGY = Population * Food * En/unit of food

GHG = Population * Food * GHG/unit of food

H_20 = Population * Food * H_20/unit of food

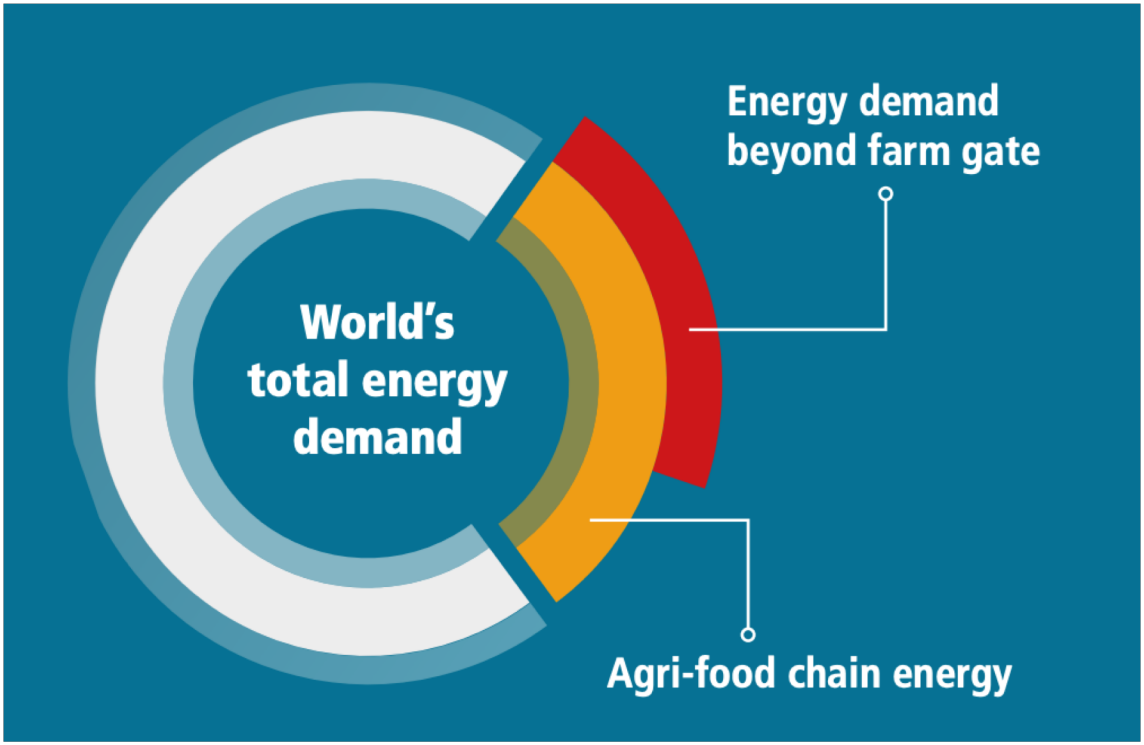
TOTAL IMPACT

ENERGY: ~20% of total energy



FAO, Aquastat
Climate Change and Food Systems (2012)
http://nationalaglawcenter.org/wp-content/uploads/assets/crs/RL32677.pdf

ENERGY USE



https://www.greenbiz.com/article/how-addressing-energy-used-food-processing-contributes-more-sustainable-agriculture

TOTAL IMPACT

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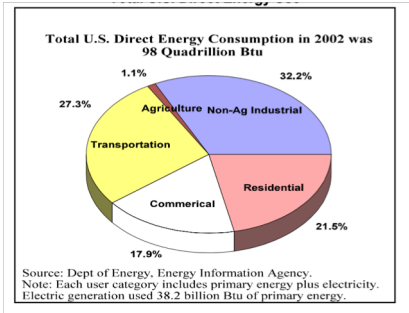

GHG: up to 25% total emission. 6 Bton (15%) from Agriculture

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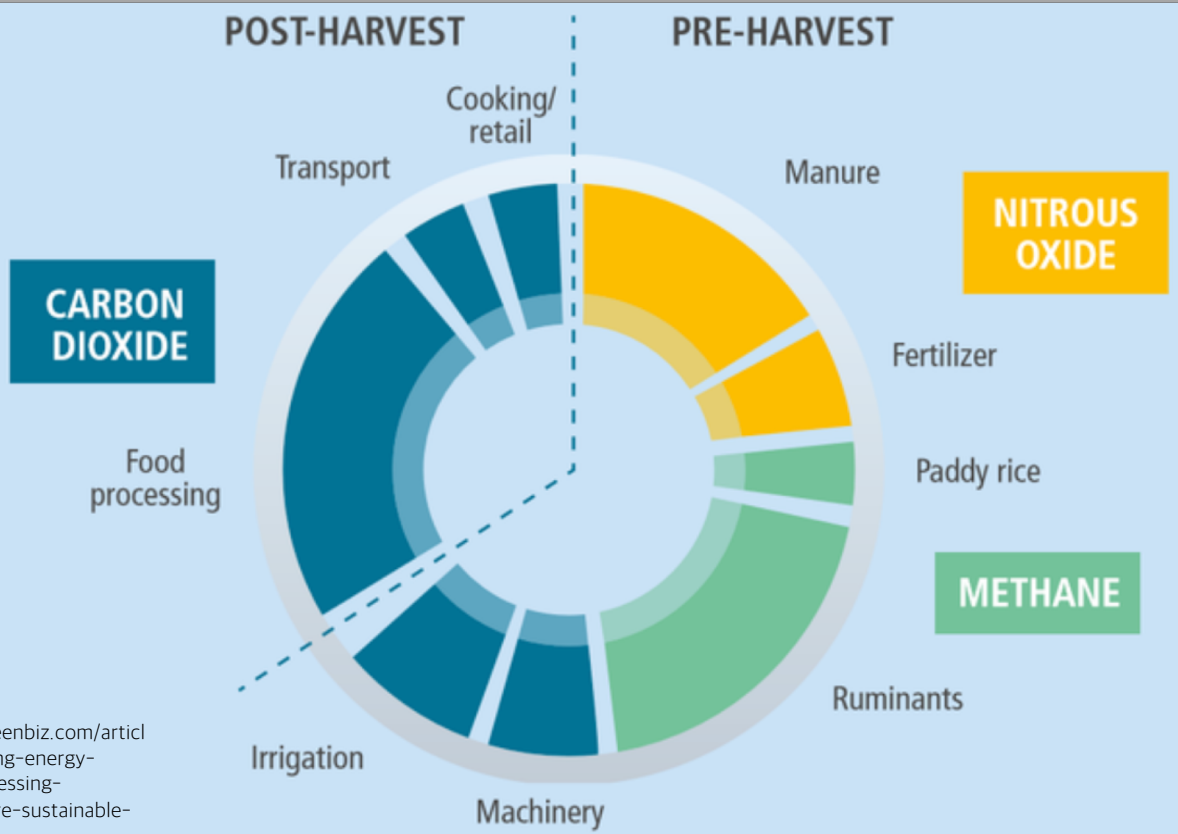
GHG EMISSIONS



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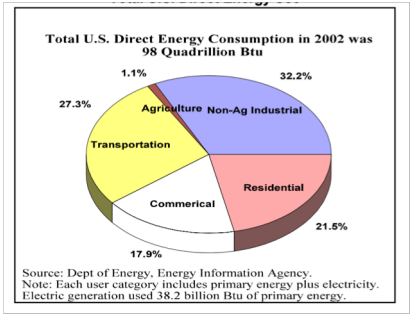
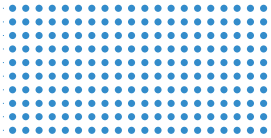
TOTAL IMPACT

ENERGY: ~20% of total energy



GHG: up to 25% total emission. 6 Bton (15%) from Agriculture

WATER: 70% of total withdrawal (~4000 km^3/y)



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TOTAL IMPACT

IMPACT = Population * Quantity * Intensity

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REDUCING FOOD QUANTITY

Definition: losses refer to the decrease in edible food mass throughout the supply chain

1/3 of the food is wasted

US: 1250day out of 3950 kcal/day available

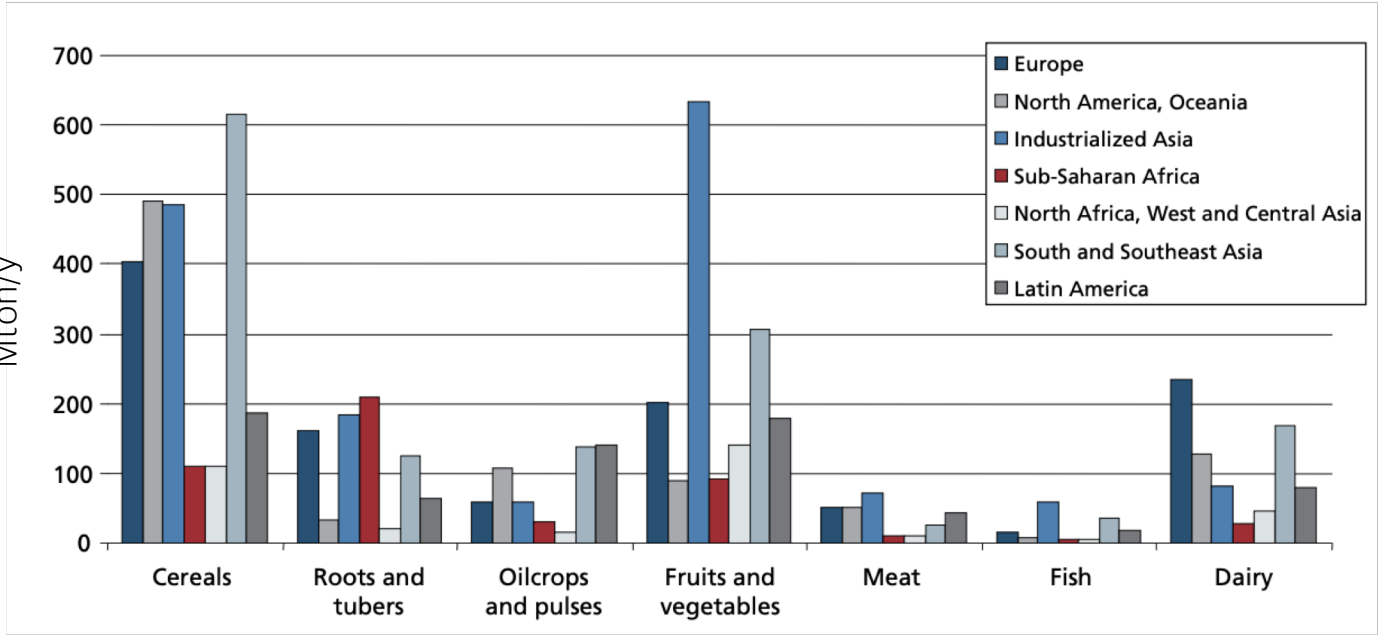
Amount of food waste

95–115 kg/year in Europe and US

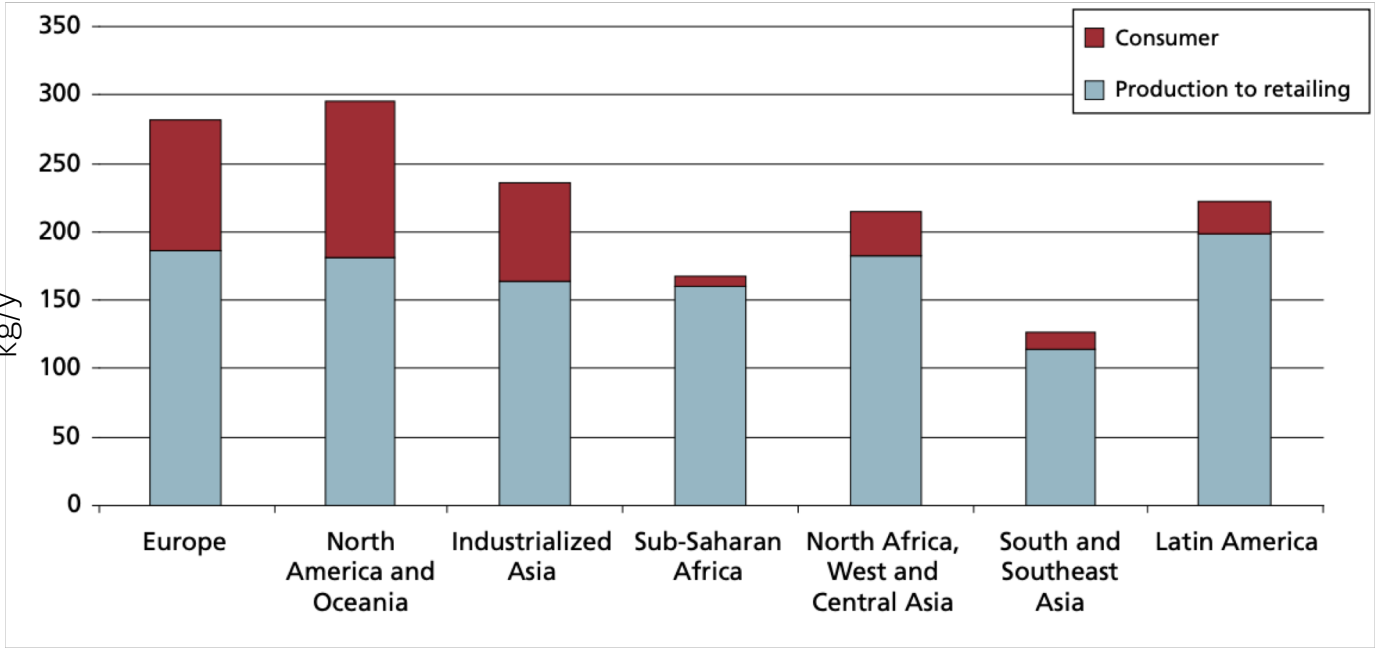
6–11 kg/year in Asia and Sub-Saharan Africa

Food waste and the food-energy-water nexus: A review of food waste management alternatives , 2018
FAO, 2011

PRODUCTION VOLUME

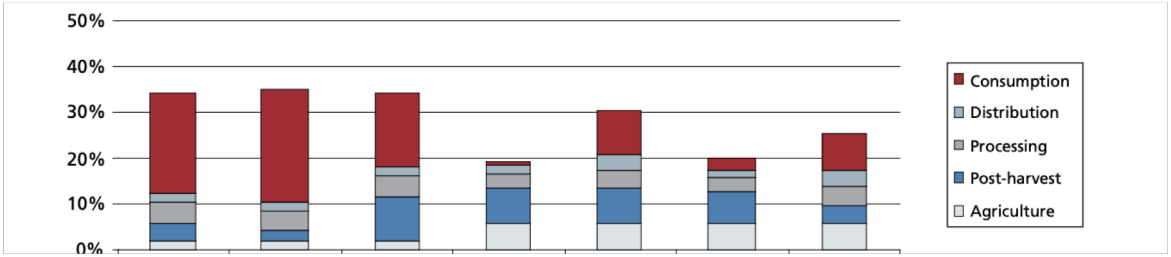


FOOD WASTE

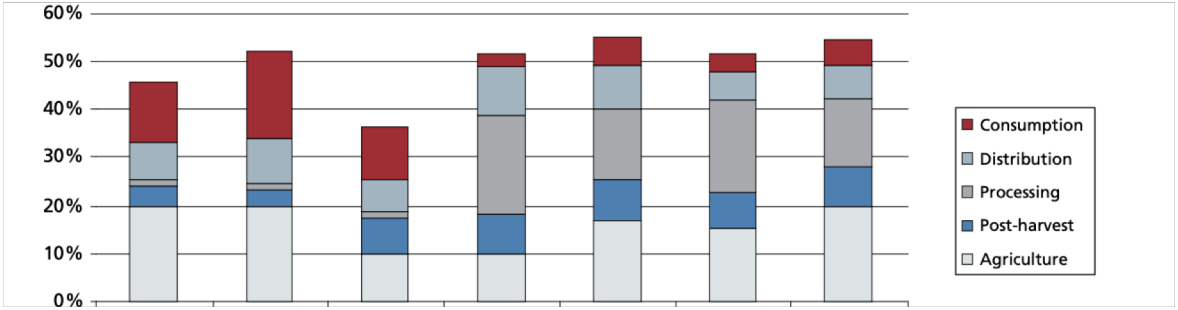

Consumer
Production to retailing
kg/y
350
300
250
200
150
100
50
0
Europe
North America and Oceania
Industrialized Asia
Sub-Saharan Africa
North Africa, West and Central Asia
South and Southeast Asia
Latin America

REDUCING FOOD QUANTITY

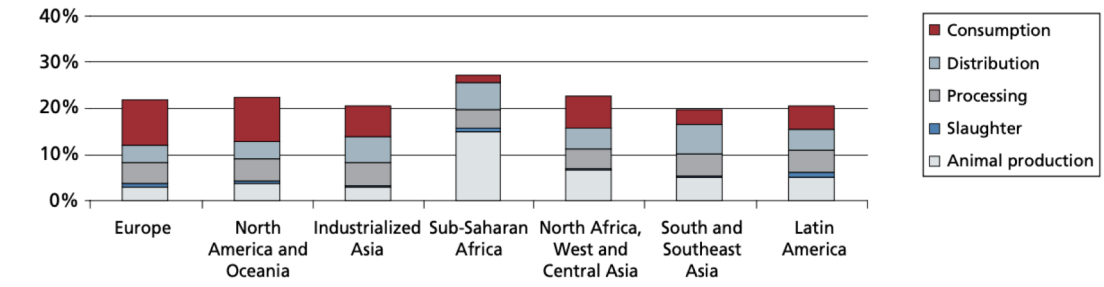
Crop



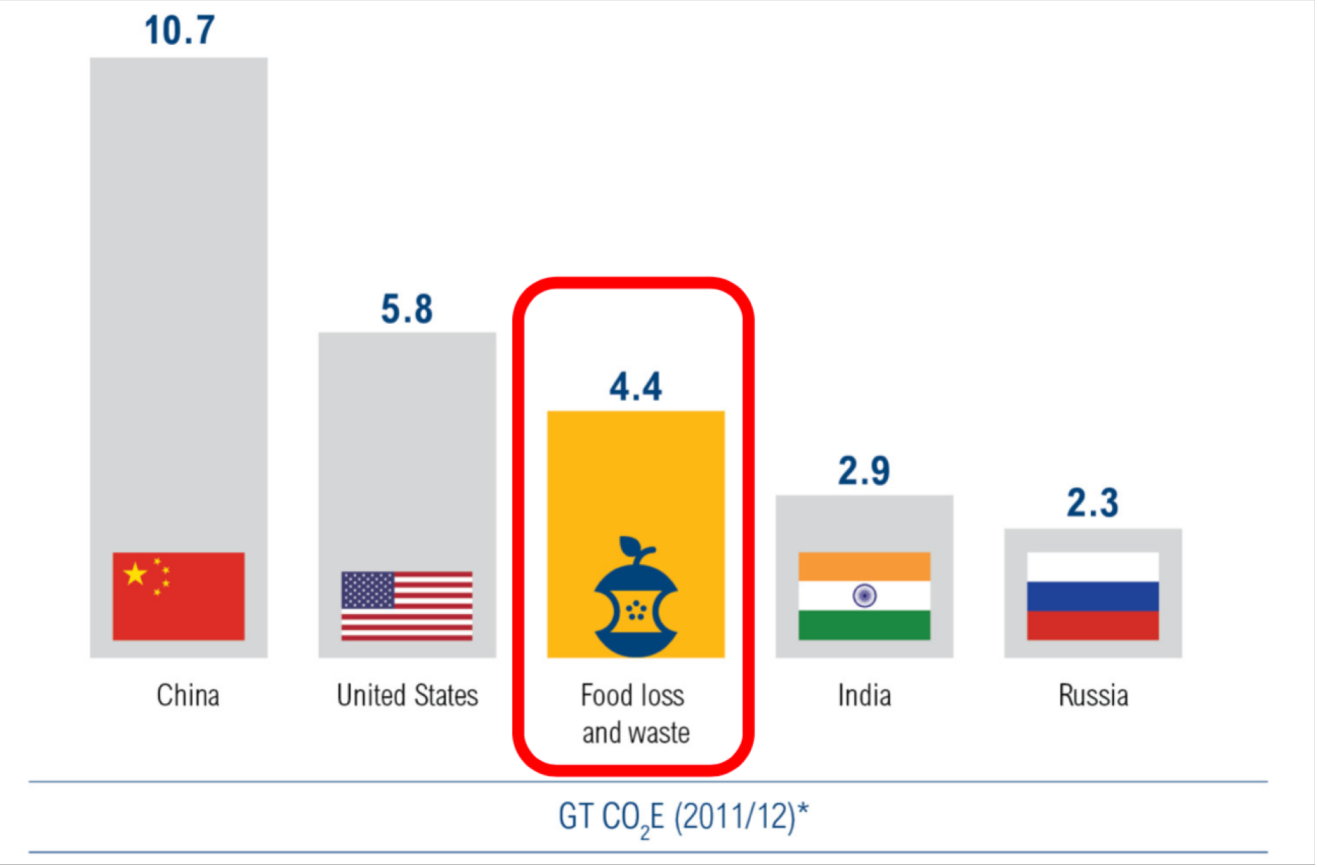
Fruit



Meat



FOODWASTE EMISSION



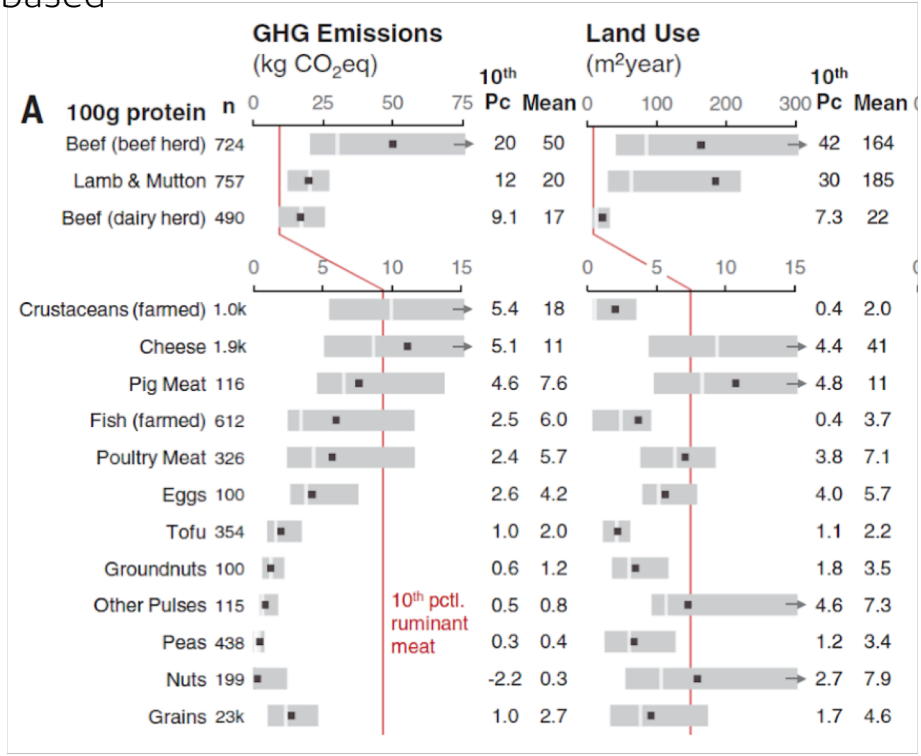
World Resource Institute

TOTAL IMPACT

IMPACT = Population * Quantity * Intensity

EMISSION INTENSITY

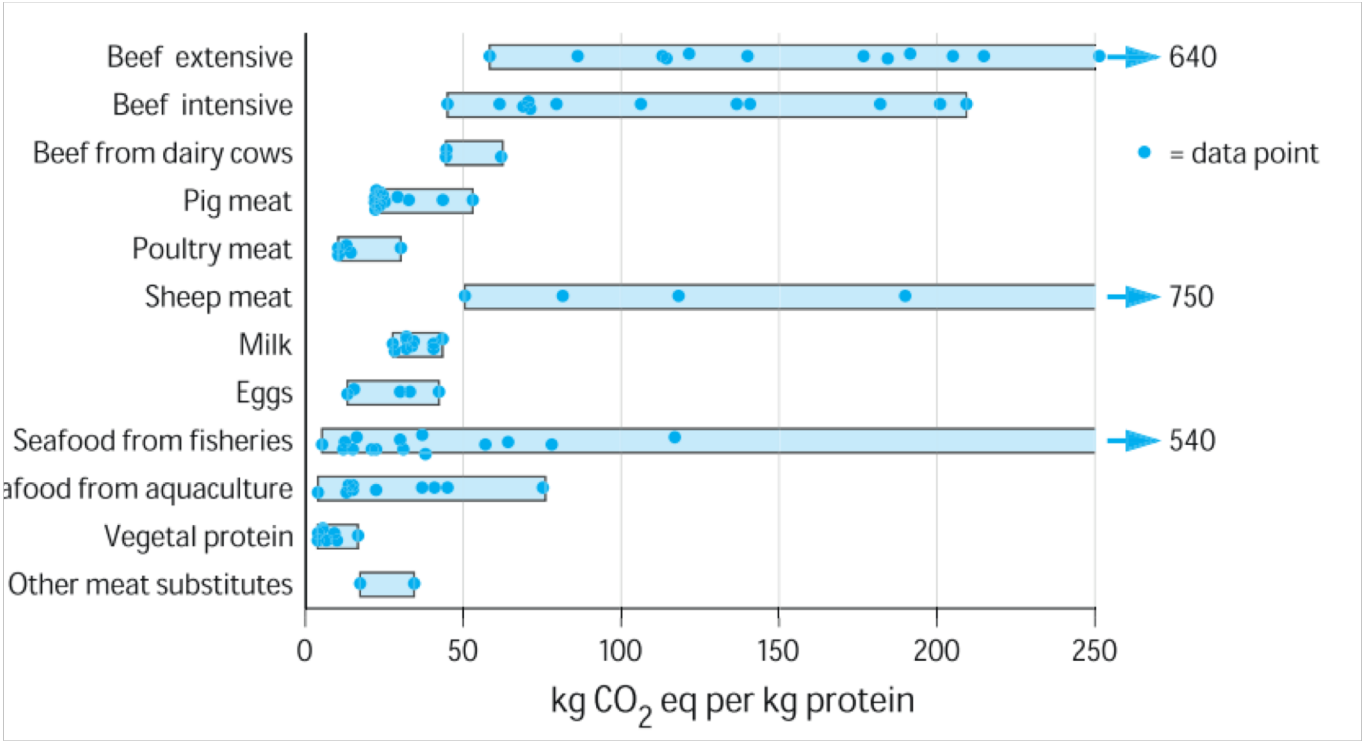
- Dataset: 38,700 farms; and 1600 processors, packaging types, and retailers.
- Protein-based



Reducing food's environmental impacts through producers and consumers (2018)

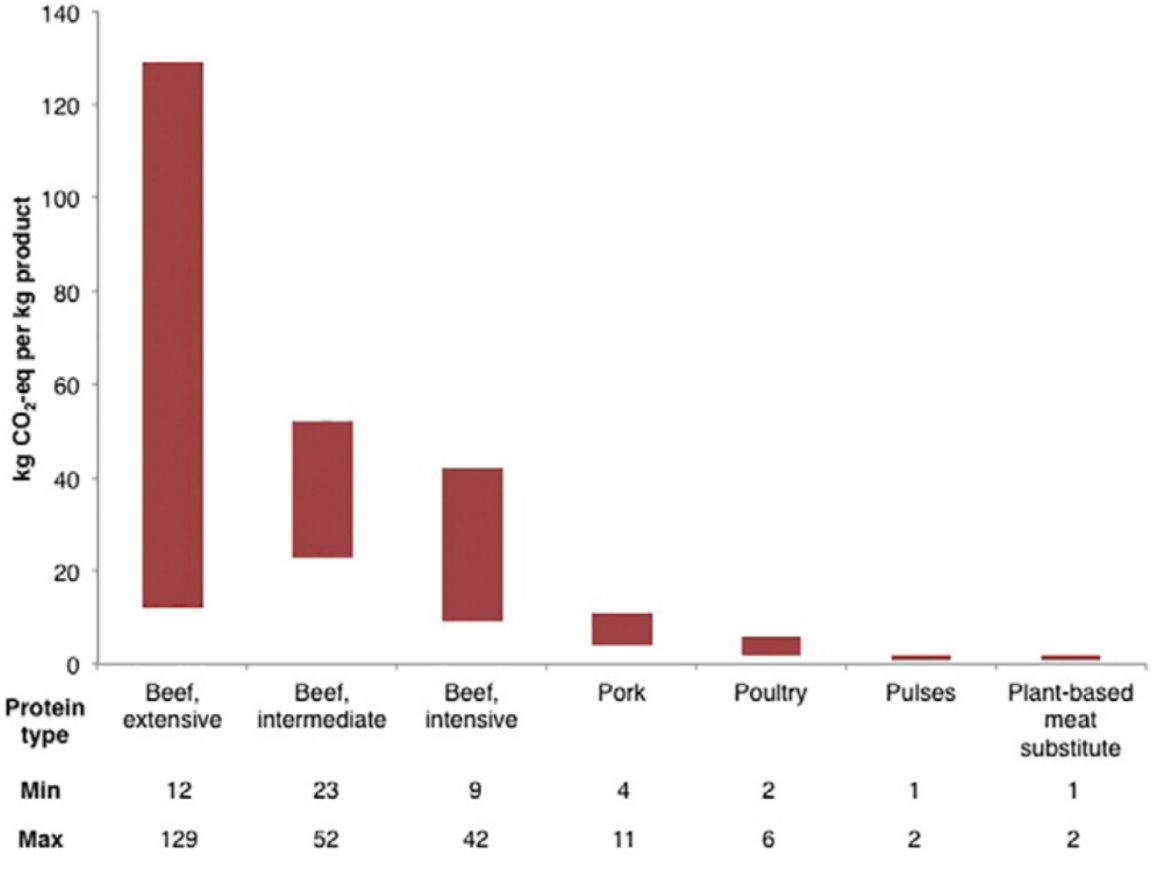
EMISSION INTENSITY

- Dataset: 30 LCA studies



The price of protein: Review of land use and carbon footprints from life cycle assessments of animal food products and their substitutes (2012)

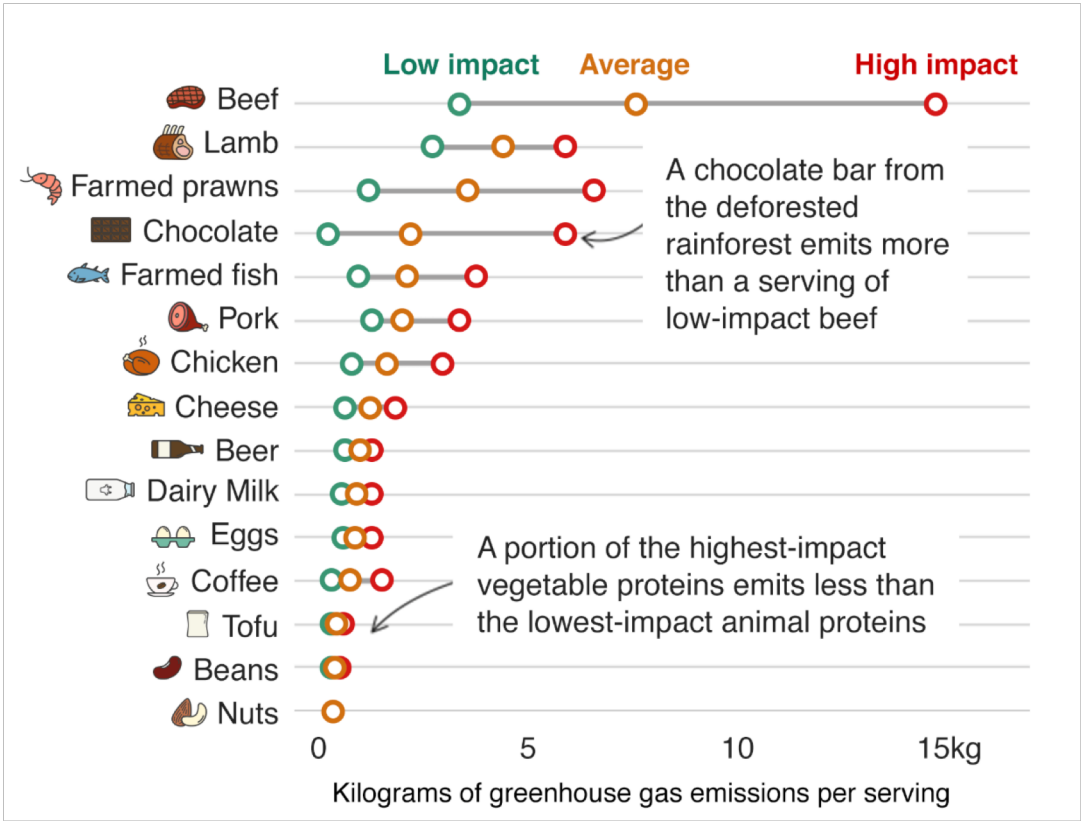
EMISSION INTENSITY



Protein type	Beef, extensive	Beef, intermediate	Beef, intensive	Pork	Poultry	Pulses	Plant-based meat substitute
Min	12	23	9	4	2	1	1
Max	129	52	42	11	6	2	2

Reducing the environmental impact of global diet (2018)

EMISSION INTENSITY



https://www.bbc.com/news/science-environment-46459714

INEFFICIENCY

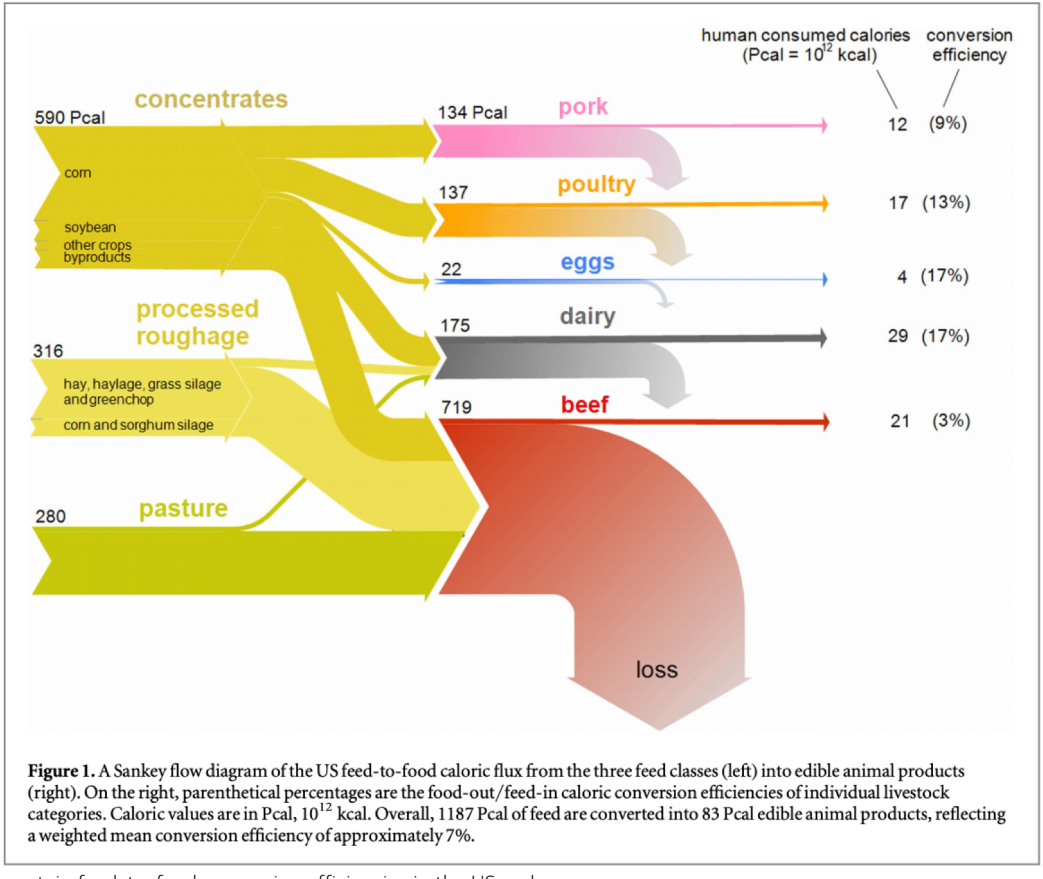
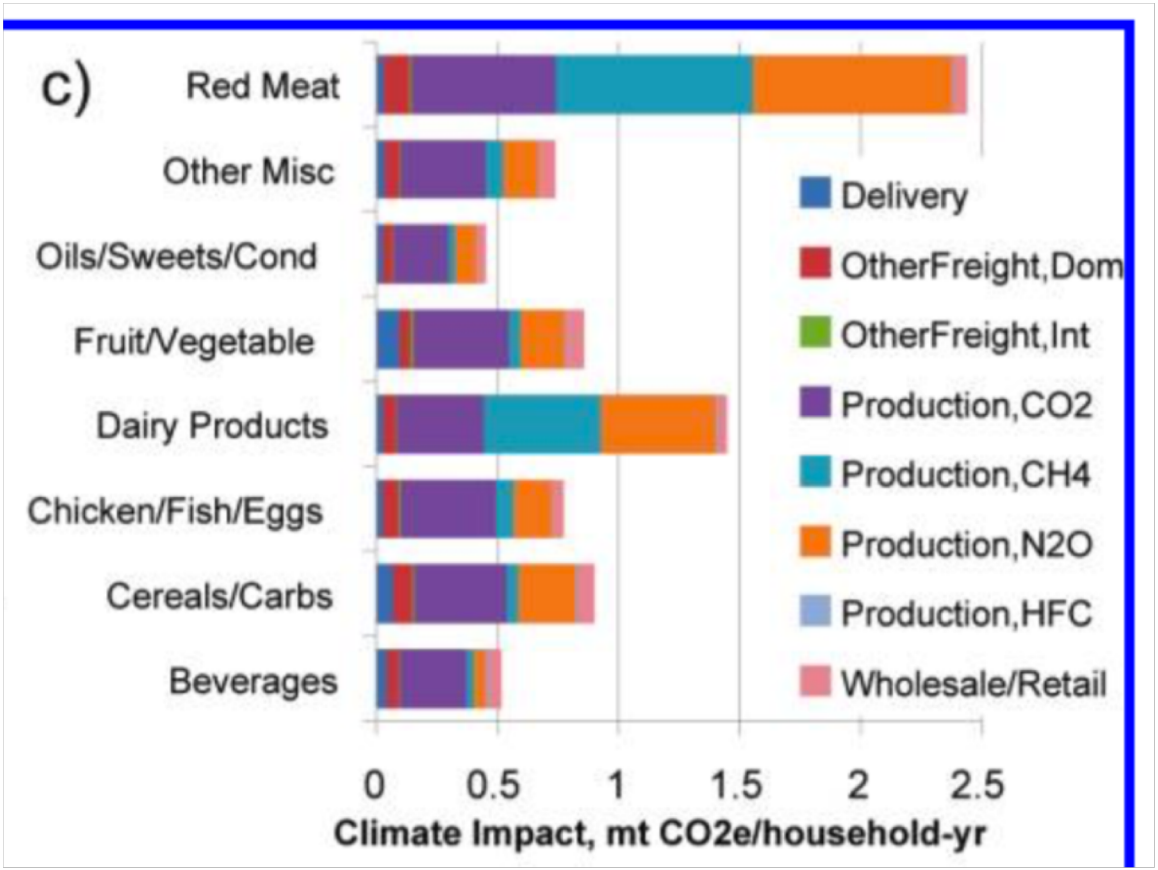


Figure 1. A Sankey flow diagram of the US feed-to-food caloric flux from the three feed classes (left) into edible animal products (right). On the right, parenthetical percentages are the food-out/feed-in caloric conversion efficiencies of individual livestock categories. Caloric values are in Pcal, 10^{12} kcal. Overall, 1187 Pcal of feed are converted into 83 Pcal edible animal products, reflecting a weighted mean conversion efficiency of approximately 7%.

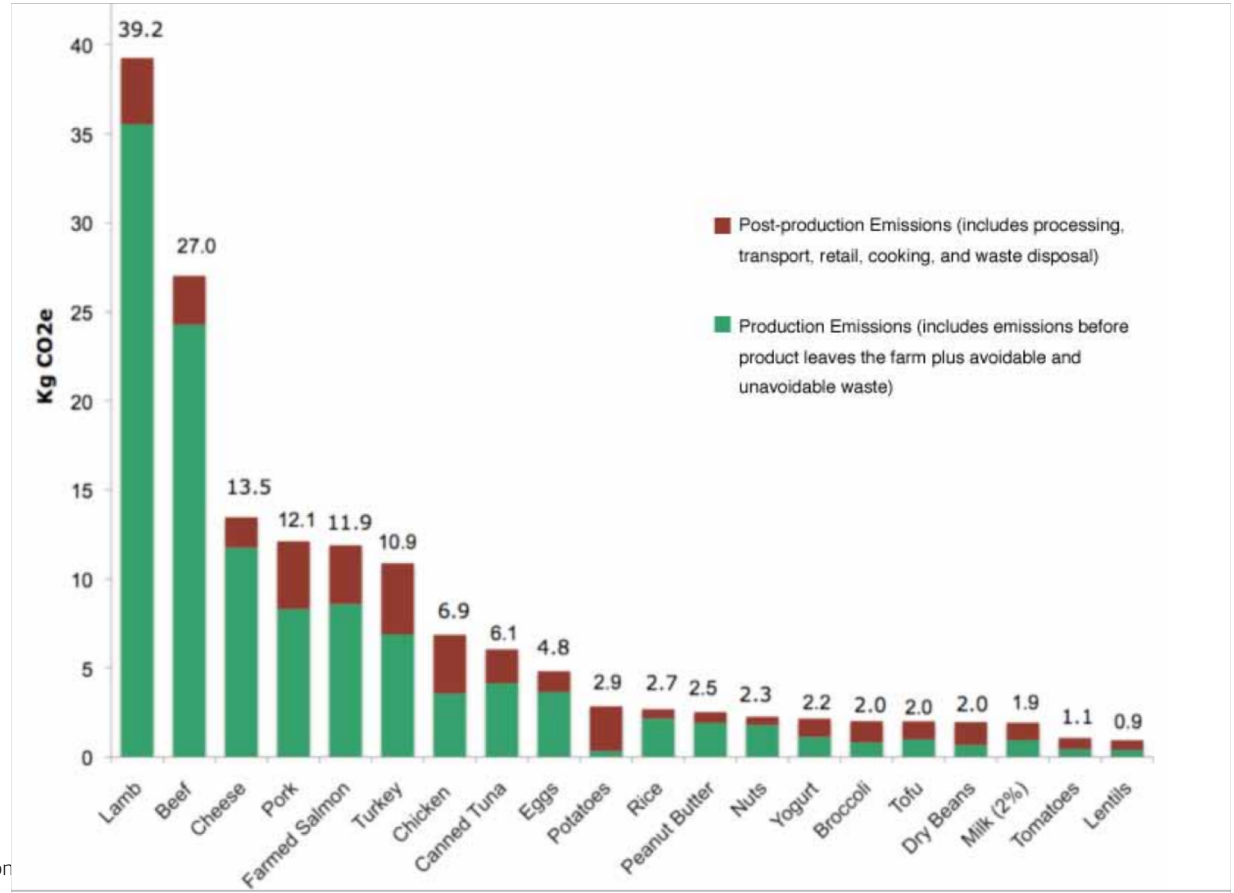
Energy and protein feed-to-food conversion efficiencies in the US and potential food security gains from dietary changes (2016)

EMISSION INTENSITY (by sector)



Food-Miles and the Relative Climate Impacts of Food Choices in the United States (2008)

EMISSION INTENSITY (by sector)

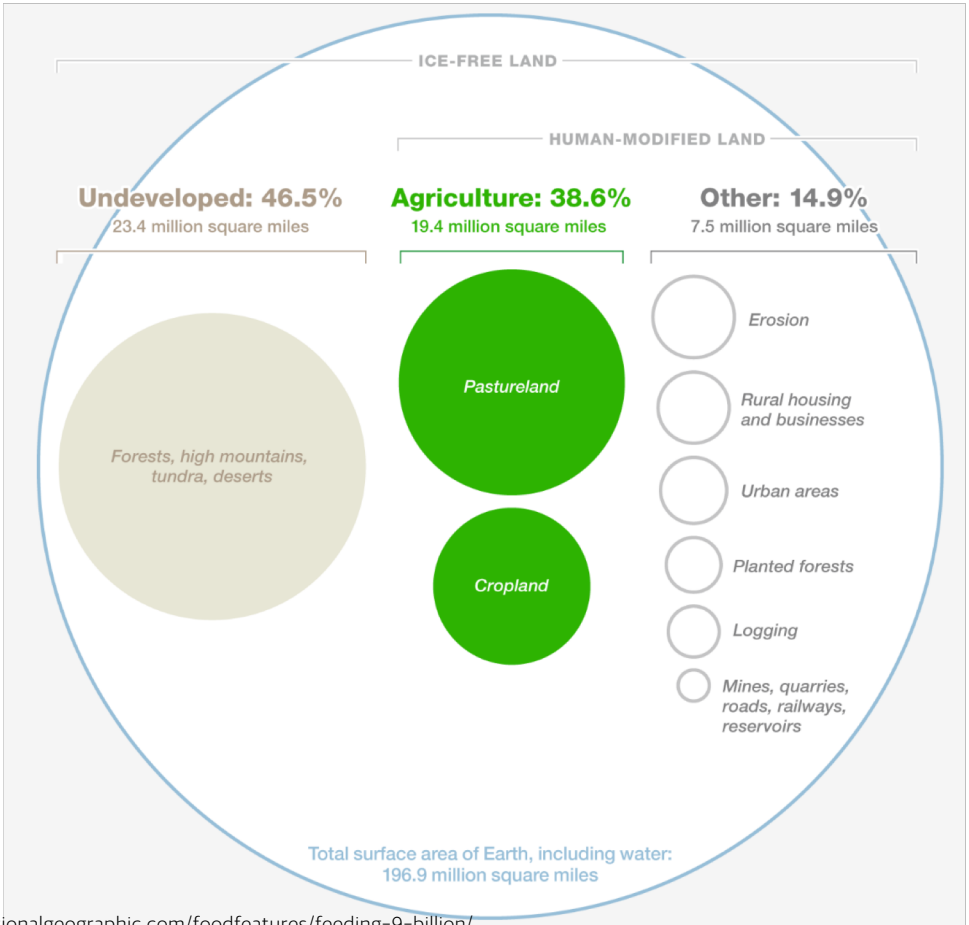


TRANSPORT

	MJ/t-km	t CO_2e/t-km $\times$ 10^6
inland water	0.3	21
rail	0.3	18
truck	2.7	180
air[a]	10.0	680[a]
oil pipeline	0.2	16
gas pipeline	1.7	180
int. air[a]	10.0	680[a]
int. water container	0.2	14
int. water bulk	0.2	11
int. water tanker	0.1	7

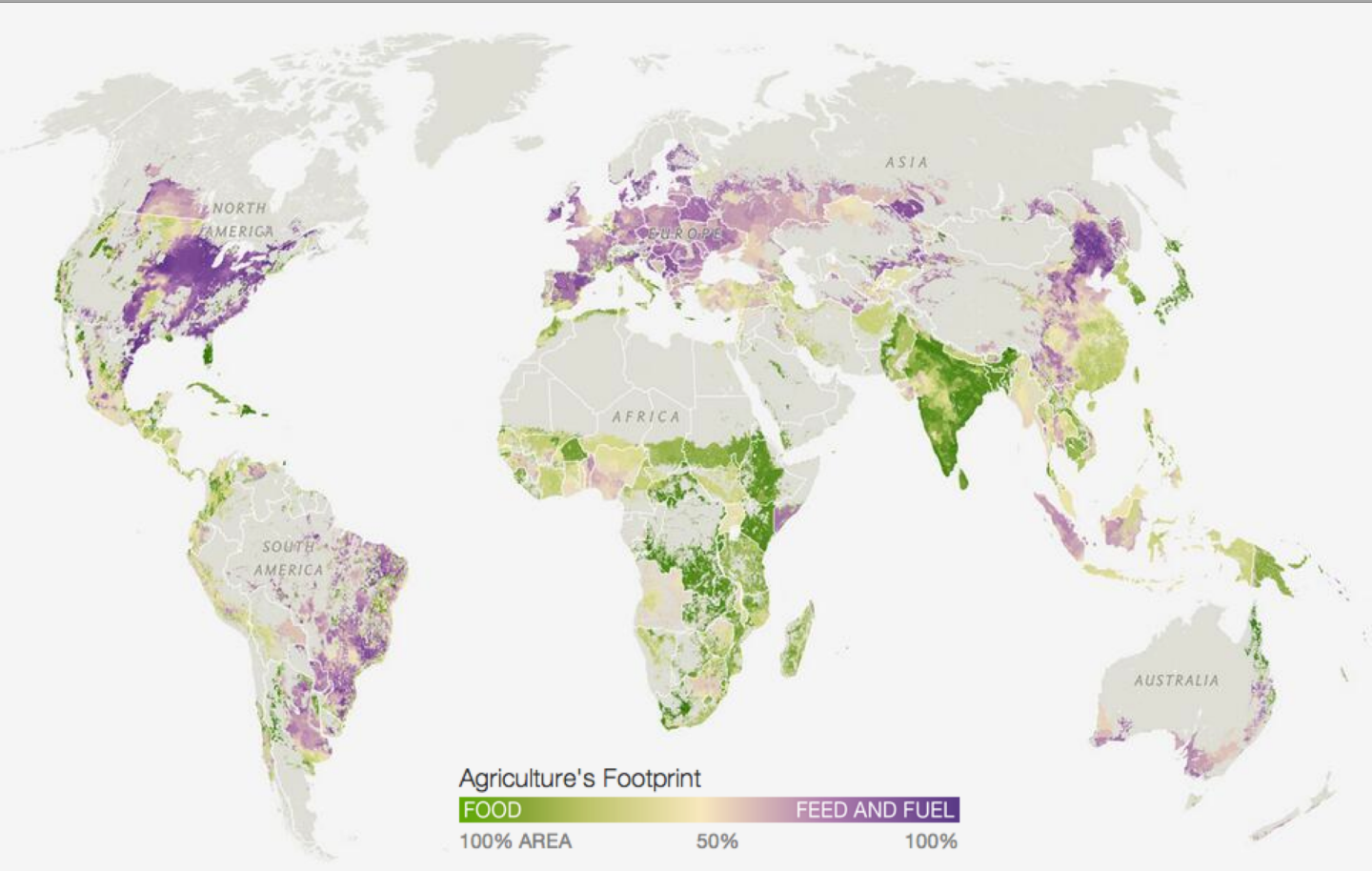
Food-Miles and the Relative Climate Impacts of Food Choices in the United States (2008)

LAND USE DILEMMA



https://www.nationalgeographic.com/foodfeatures/feeding-9-billion/

FOOD vs FEED/FUEL



https://www.nationalgeographic.com/foodfeatures/feeding-9-billion/

FOOD vs FEED/FUEL

WORLD

- 55% of the world's crop calories are actually eaten directly by people.
- 36% for animal feed
- 9% goes toward biofuels and other industrial uses

US

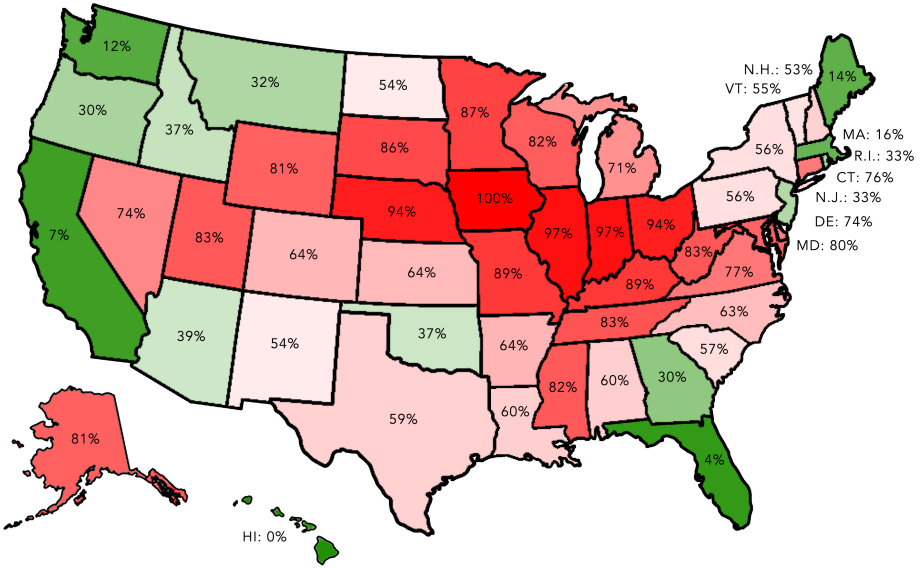
- 95% of oat production for animal feed
- 80% of corn production for animal feed.

https://www.vox.com/2014/8/21/6053187/cropland-map-food-fuel-animal-feed
https://www.smithsonianmag.com/travel/is-the-livestock-industry-destroying-the-planet-11308007/

FOOD vs FEED

Human Food vs. Animal Feed

The percentage of each state's agricultural income derived from crops grown primarily for animal consumption

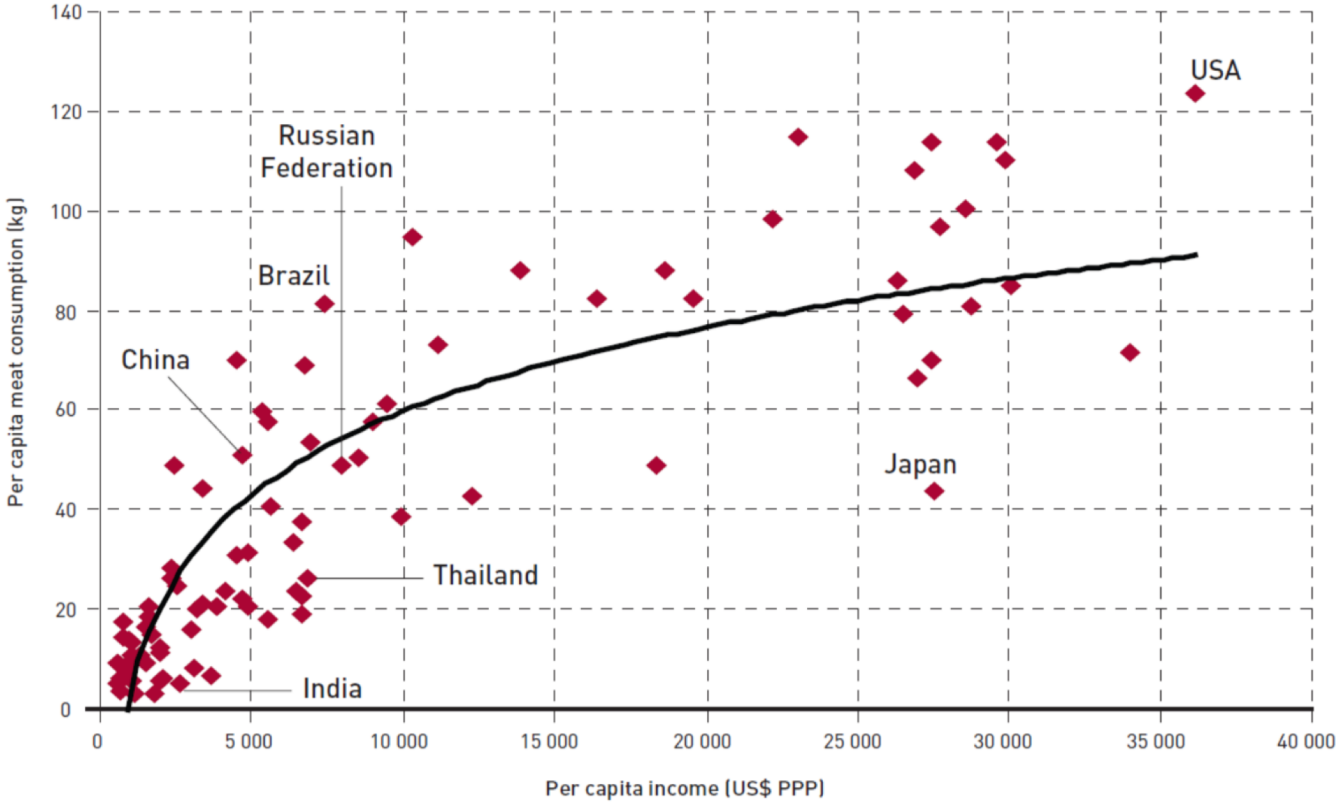


Created by Joe Satran of The Huffington Post. Data Source: USDA NASS, HuffPost Calculations. "Crops grown primarily for animal feed" refers to field corn, soybeans, hay, barley and sorghum.Income from tobacco, cotton and other non-edible crops is not included.

FUTURE SCENARIO

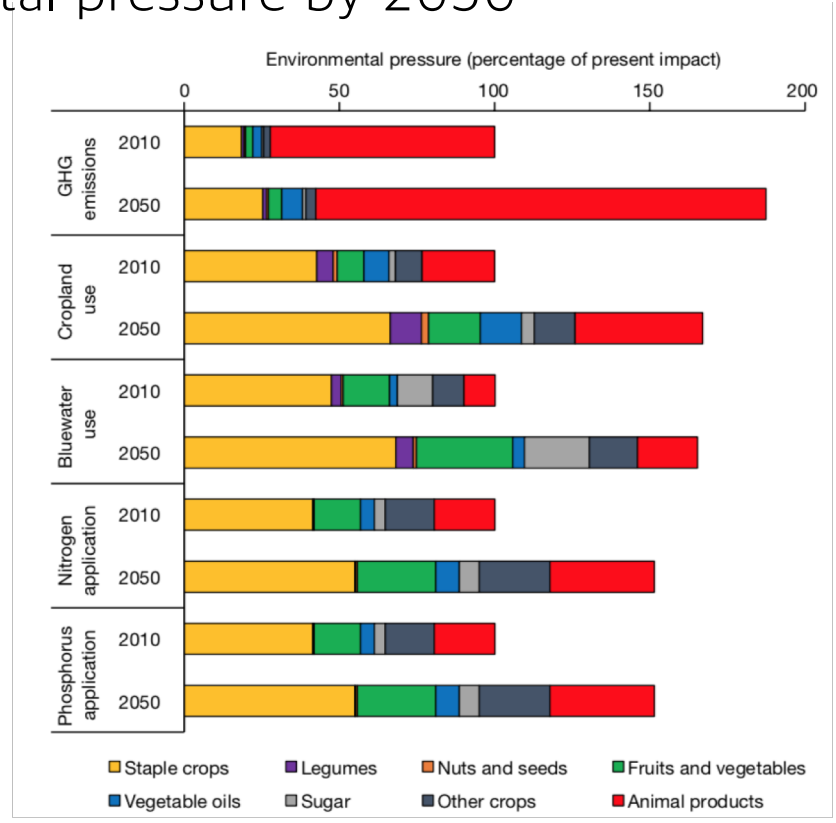
https://www.nationalgeographic.com/foodfeatures/feeding-9-billion/

Meat consumption and per capita income - 2002



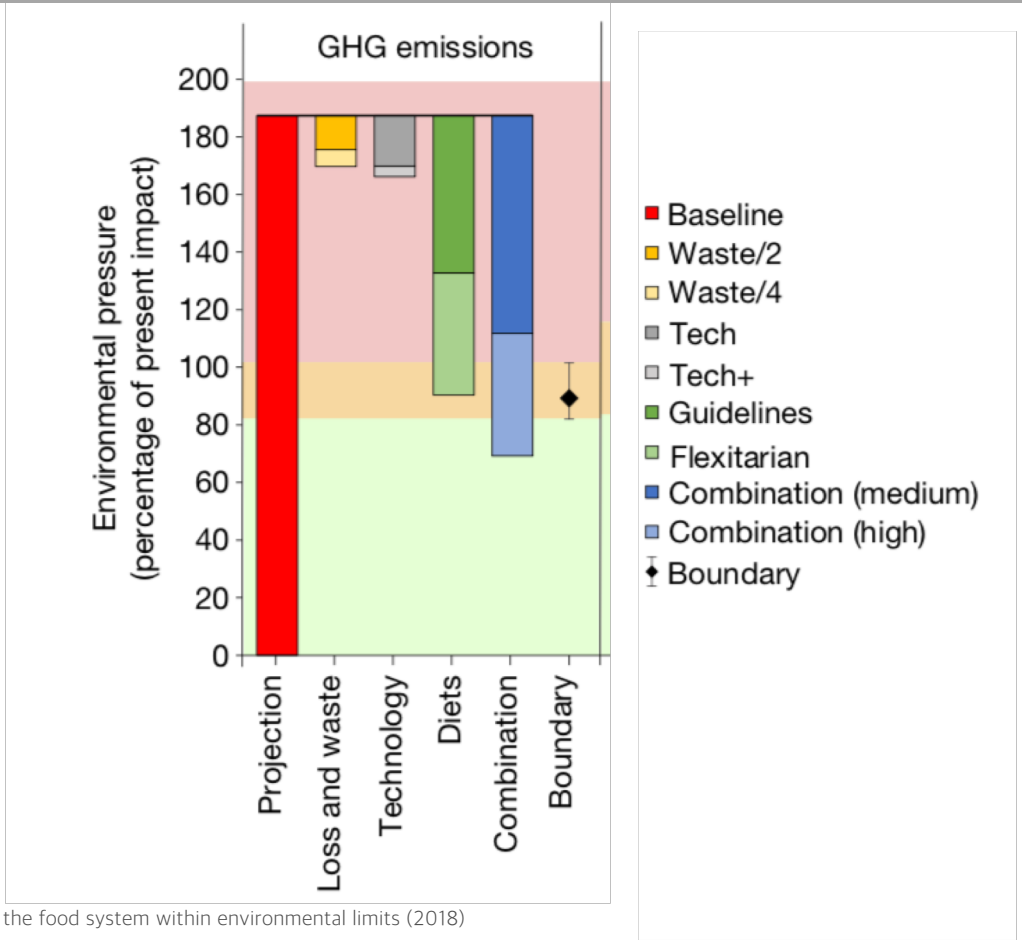
FUTURE SCENARIO

Environmental pressure by 2050



Options for keeping the food system within environmental limits (2018)

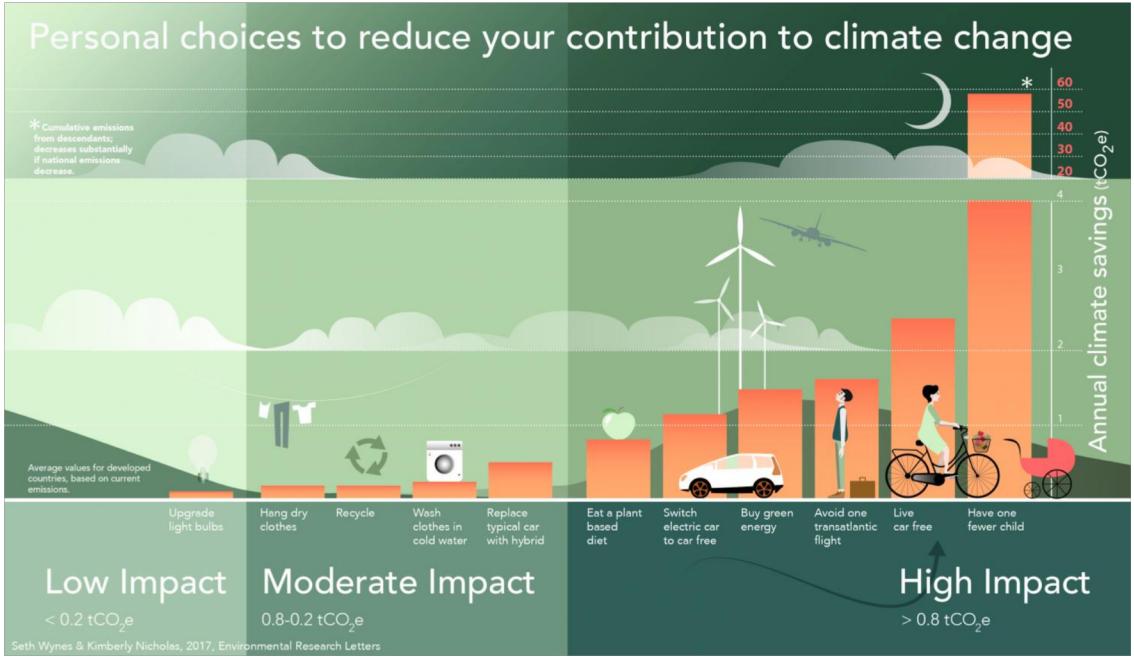
FUTURE SCENARIO



Options for keeping the food system within environmental limits (2018)

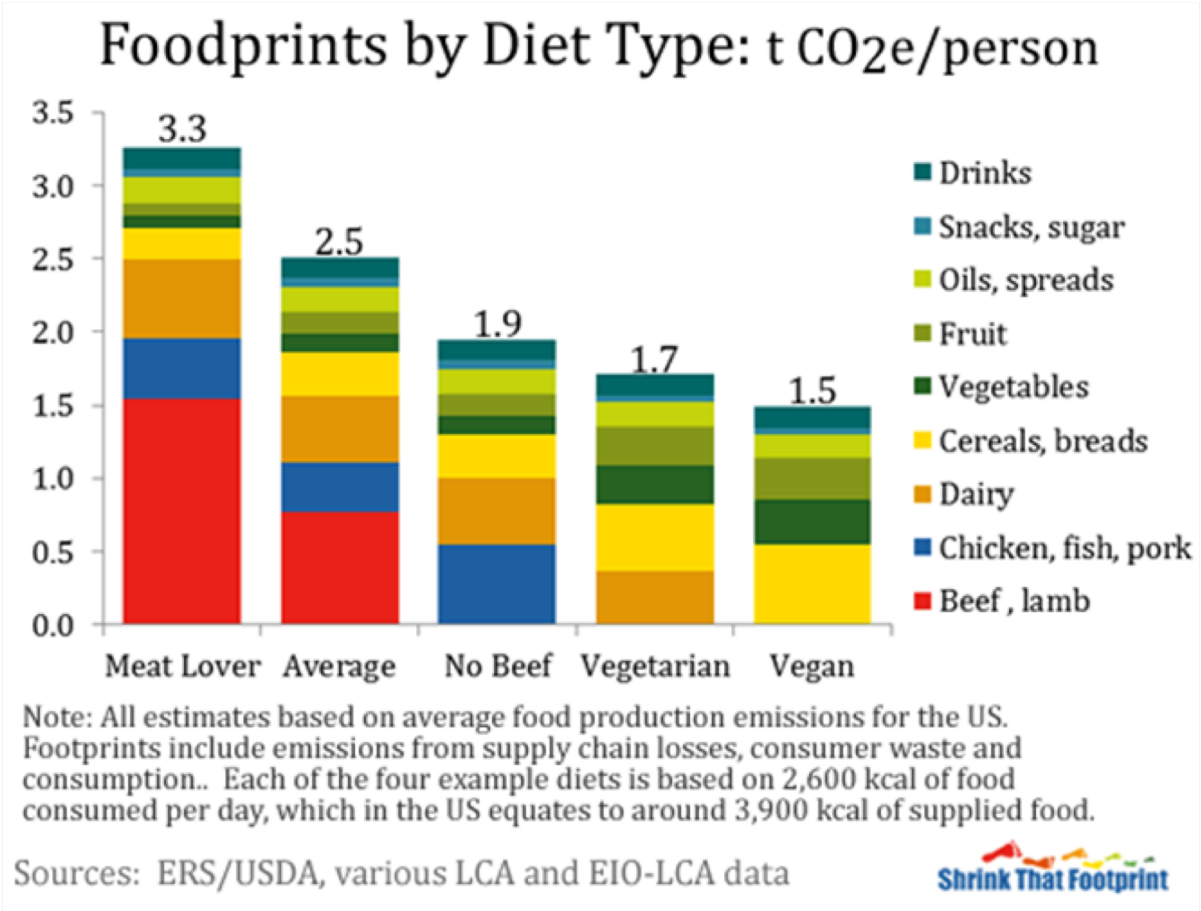
CONCLUSIONS

- Consume foods lower on the food chain
- Avoid energy-intensive production
- Avoid energy-intensive transportation



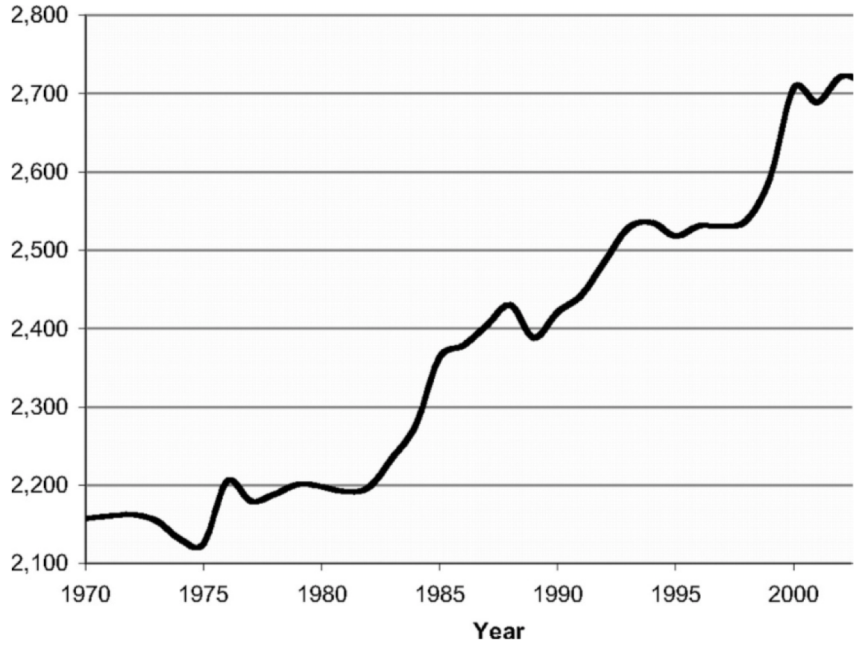
The climate mitigation gap: education and government recommendations miss the most effective individual actions (2017)

BACK UP

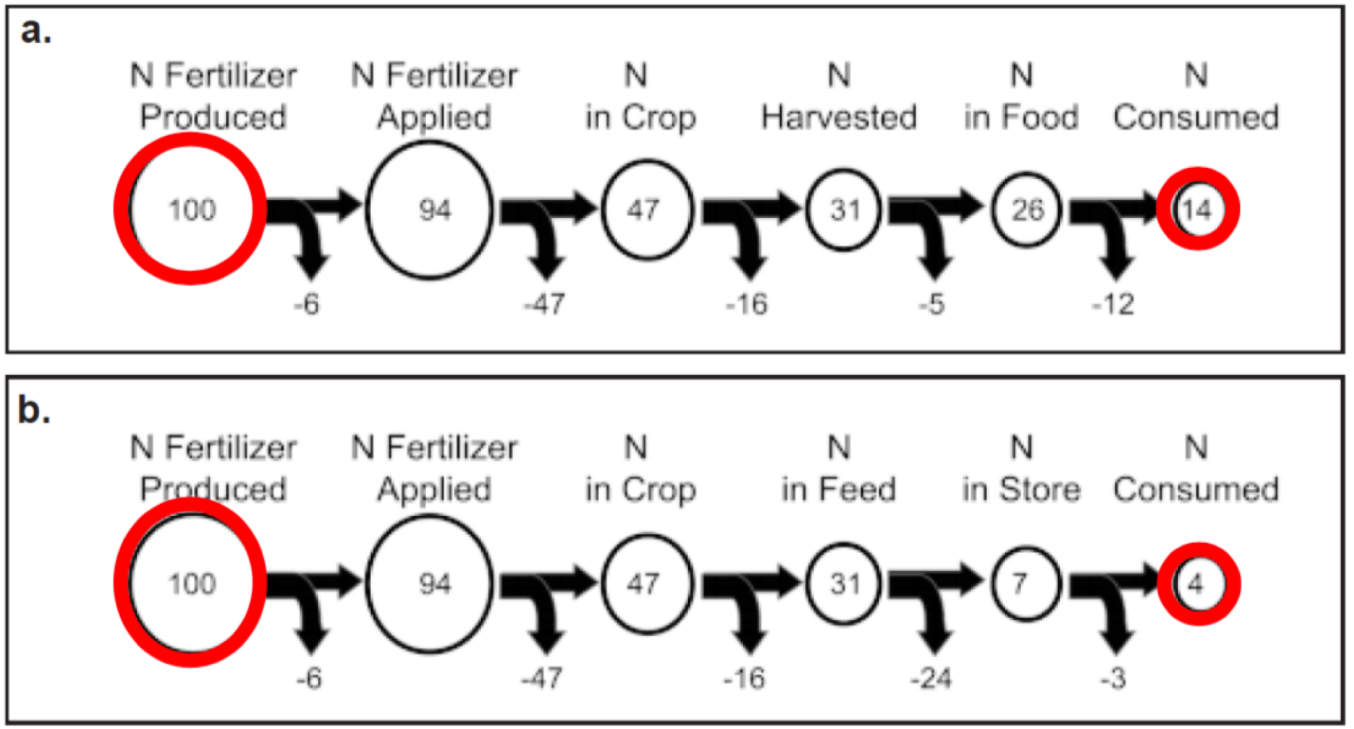

Foodprints by Diet Type: t CO2e/person
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3.3
2.5
1.9
1.7
1.5
Meat Lover
Average
No Beef
Vegetarian
Vegan
Drinks
Snacks, sugar
Oils, spreads
Fruit
Vegetables
Cereals, breads
Dairy
Chicken, fish, pork
Beef , lamb
Note: All estimates based on average food production emissions for the US. Footprints include emissions from supply chain losses, consumer waste and consumption.. Each of the four example diets is based on 2,600 kcal of food consumed per day, which in the US equates to around 3,900 kcal of supplied food.
Sources: ERS/USDA, various LCA and EIO-LCA data
Shrink That Footprint

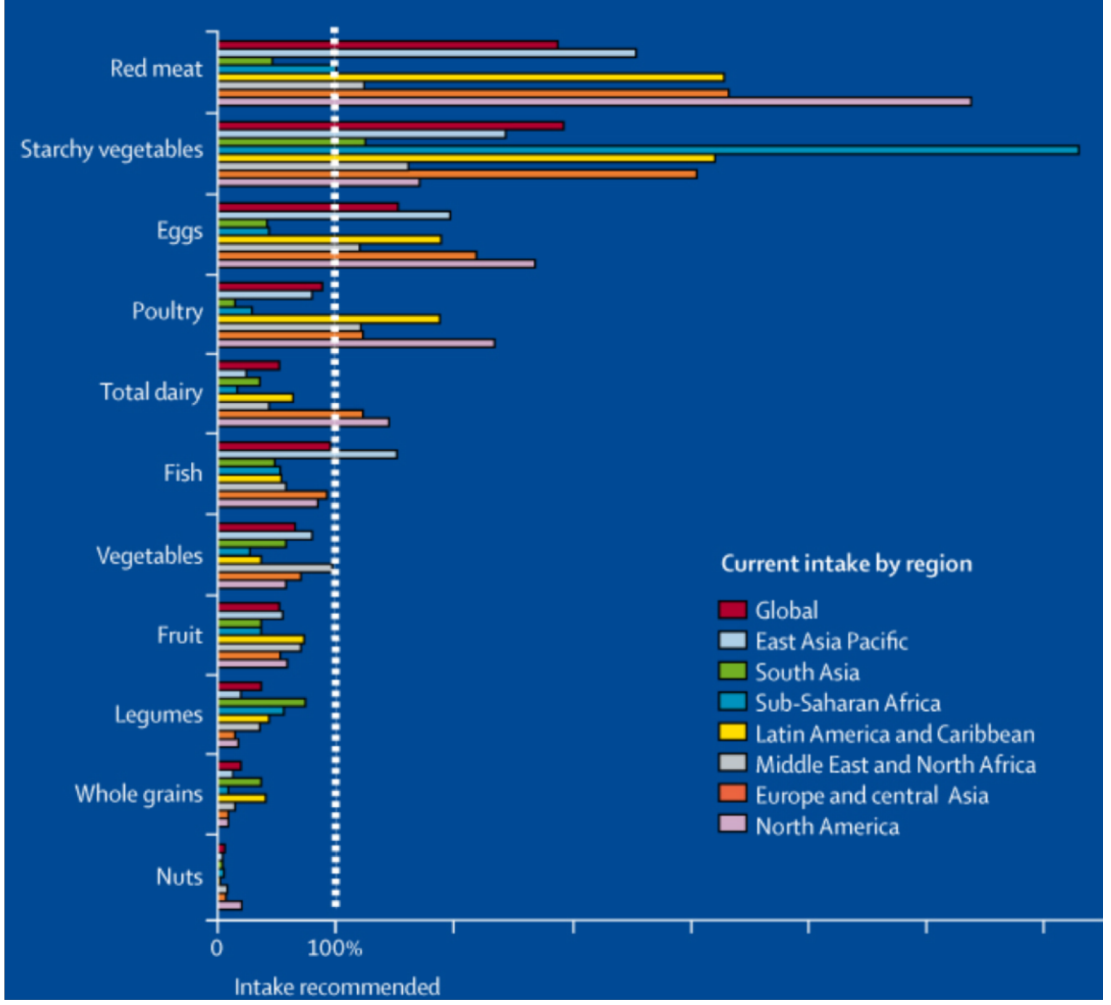
Per capita daily caloric intake

USDA Economic Research Service
loss-adjusted availability, 1970–2005



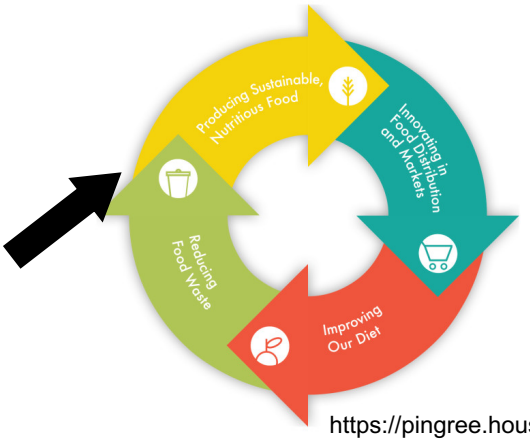
(White J S Am J Clin Nutr 2008;88:1716S-1721S)


a.
N Fertilizer Produced
N Fertilizer Applied
N in Crop
N Harvested
N in Food
N Consumed
100
94
47
31
26
14
-6
-47
-16
-5
-12
b.
N Fertilizer Produced
N Fertilizer Applied
N in Crop
N in Feed
N in Store
N Consumed
100
94
47
31
7
4
-6
-47
-16
-24
-3

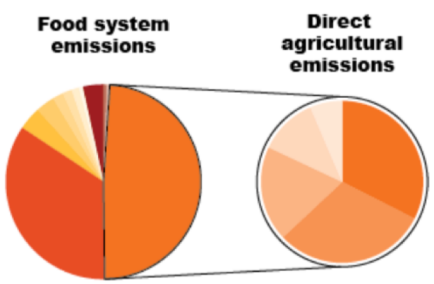


https://www.thelancet.com/

Reducing Food Waste



https://pingree.house.gov/

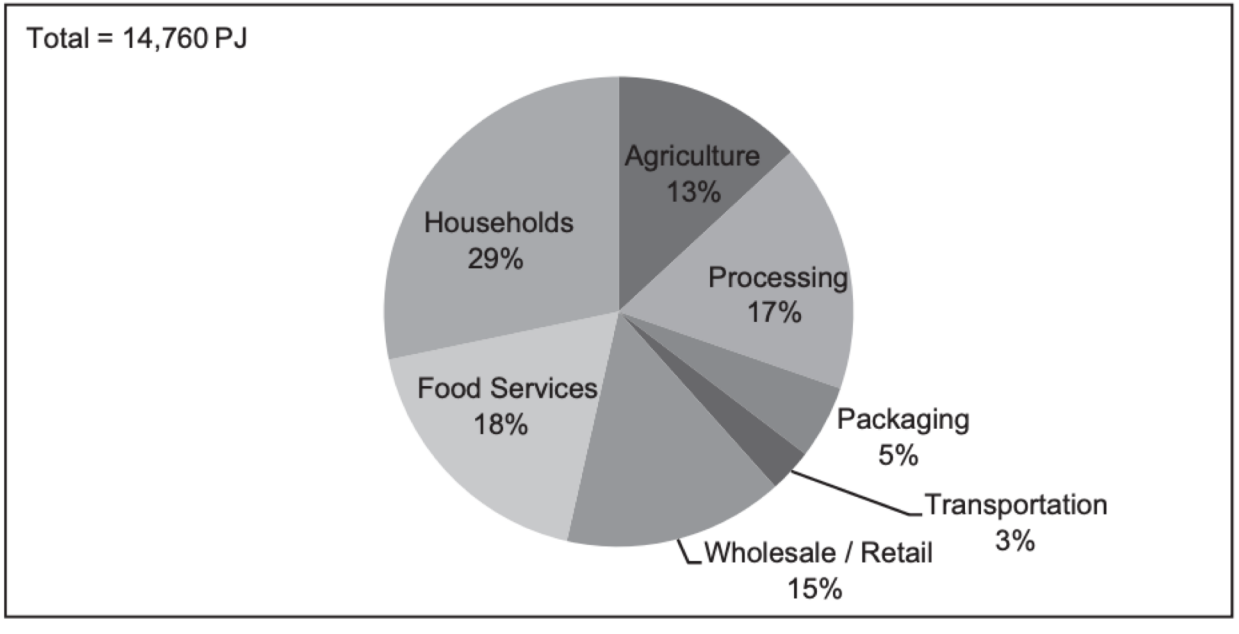


PREPRODUCTION
- Fertilizer manufacture **3%**
- Pesticide production **0.6%**
- Energy use in animal feed production **0.5%**

PRODUCTION
- Direct emissions **48.5%**
- Indirect emissions (deforestation) **35%**

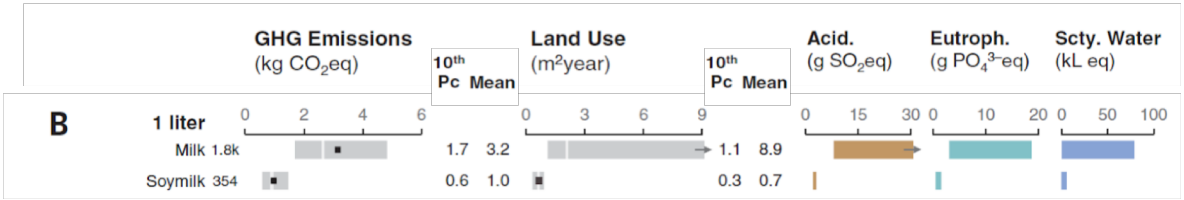
POSTPRODUCTION
- Refrigeration **4%**
- Storage, packaging, and transport **3%**
- Retail activities **2%**
- Primary and secondary production **1.5%**
- Catering and domestic food **1.3%**
- Waste disposal **0.6%**

- Agricultural soils **32%**
- Enteric fermentation **31%**
- Other emissions **19%**
- Rice cultivation **12%**
- Manure management **6%**



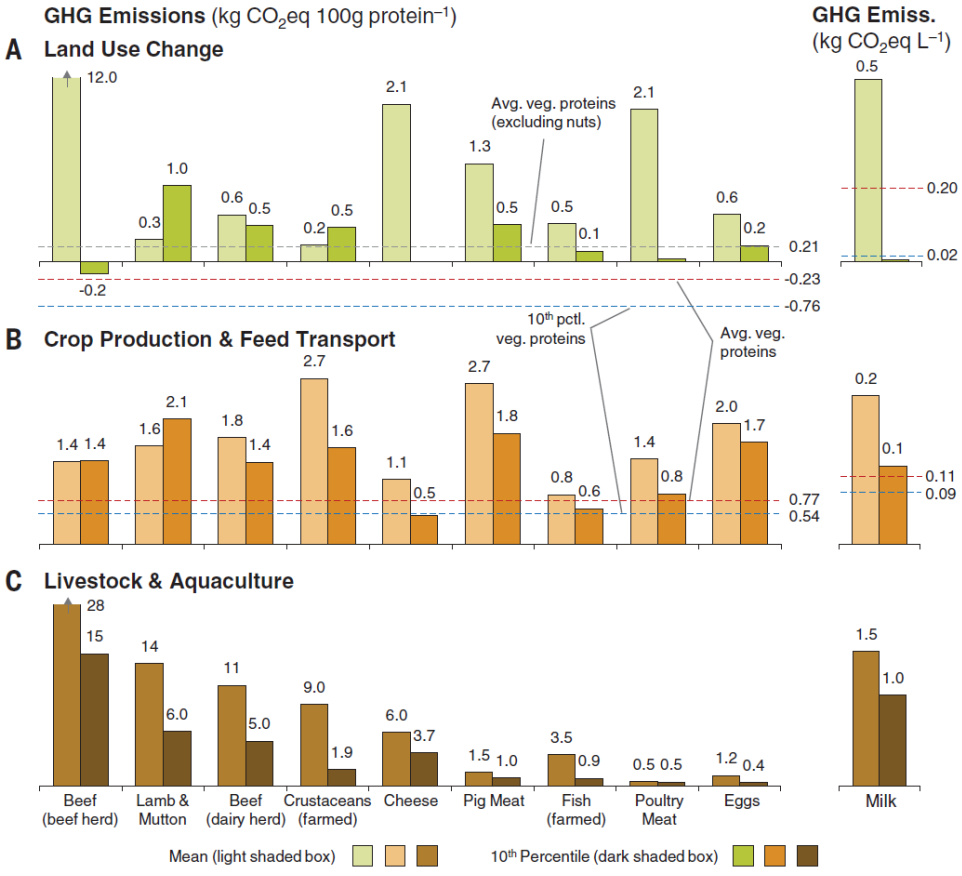
Considerations for reducing food system energy demand while scaling up urban agriculture (2017)

Relative impacts of milk



Reducing food's environmental impacts through producers and consumers (2018)

EMISSION INTENSITY (by sector)



Reducing food's environmental impacts through producers and consumers (2018)

Harvard food system initiatives

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- FLP Fellows
- Open Positions
- FLP Manager
- The Family Meals Program

FARMERS' MARKET

- Vendors
- How to Participate
- Now Hiring: Farmers' Market Asst

FOODBETTER

FOODBETTER

a partnership of Harvard University Dining Services and its' Food Literacy Project, the Harvard Office for Sustainability and the Harvard Food Law and Policy Clinic

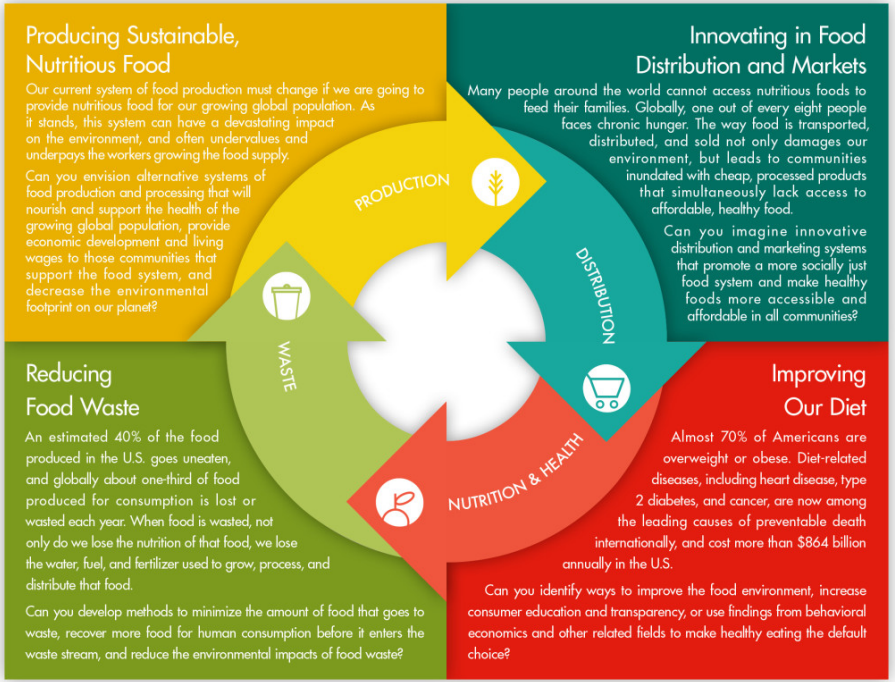
What is Food Better?

A better food system starts with you. At Harvard, we call that focus on the food system and how to improve it – how to grow better, eat better, shop better, dispose better – Food Better. Throughout the year, FoodBetter partners engage in community-wide dialogue about how we can Food Better, which includes events, field trips and more. Food Better focuses on:

Foodbetter.

Harvard food system initiatives

- Harvard i-Lab Deans' Food System Challenge 2014-2015



Harvard food system initiatives

FORWARD FOOD
THE BUSINESS CASE FOR FOODSERVICE ABOUT

- Plant-based culinary training program at Harvard founded in 2015 with the Humane Society
- Now expanded across US, Canada, Europe, and South America
- Harvard dining halls consistently have plant-based protein options & higher ratio of plants to meat

Forward Food is supported and endorsed by an array of diverse organizations, institutions and other partners who support the idea that as a society, we ought to be focusing more on plant-based foods as a means of creating a better food system.

THE HUMANE SOCIETY OF THE UNITED STATES
The Valley Hospital Valley Health System
FARMFORWARD
LEADERSHIP CIRCLE
Friends of the Earth
HUMANE SOCIETY INTERNATIONAL

Harvard food system initiatives