

# Energy Demand and Environmental Impact of Food Systems

Carlo A. Amadei  
HEJC  
March 7<sup>th</sup> 2019

# FOOD SYSTEM IMPACT

$$\text{IMPACT} = \text{Population} * \text{Quantity} * \text{Intensity}$$

# FOOD SYSTEM IMPACT

IMPACT = Population \* Quantity \* Intensity

ENERGY = Population \* Food \* En/unit of food

# FOOD SYSTEM IMPACT

$\text{IMPACT} = \text{Population} * \text{Quantity} * \text{Intensity}$

$\text{ENERGY} = \text{Population} * \text{Food} * \text{En/unit of food}$

$\text{GHG} = \text{Population} * \text{Food} * \text{GHG/unit of food}$

# FOOD SYSTEM IMPACT

$\text{IMPACT} = \text{Population} * \text{Quantity} * \text{Intensity}$

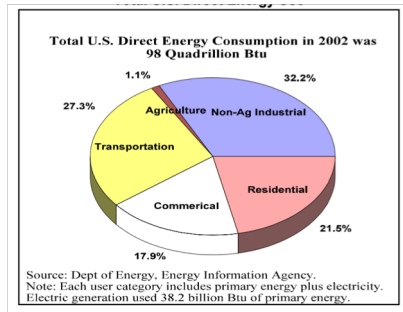
$\text{ENERGY} = \text{Population} * \text{Food} * \text{En/unit of food}$

$\text{GHG} = \text{Population} * \text{Food} * \text{GHG/unit of food}$

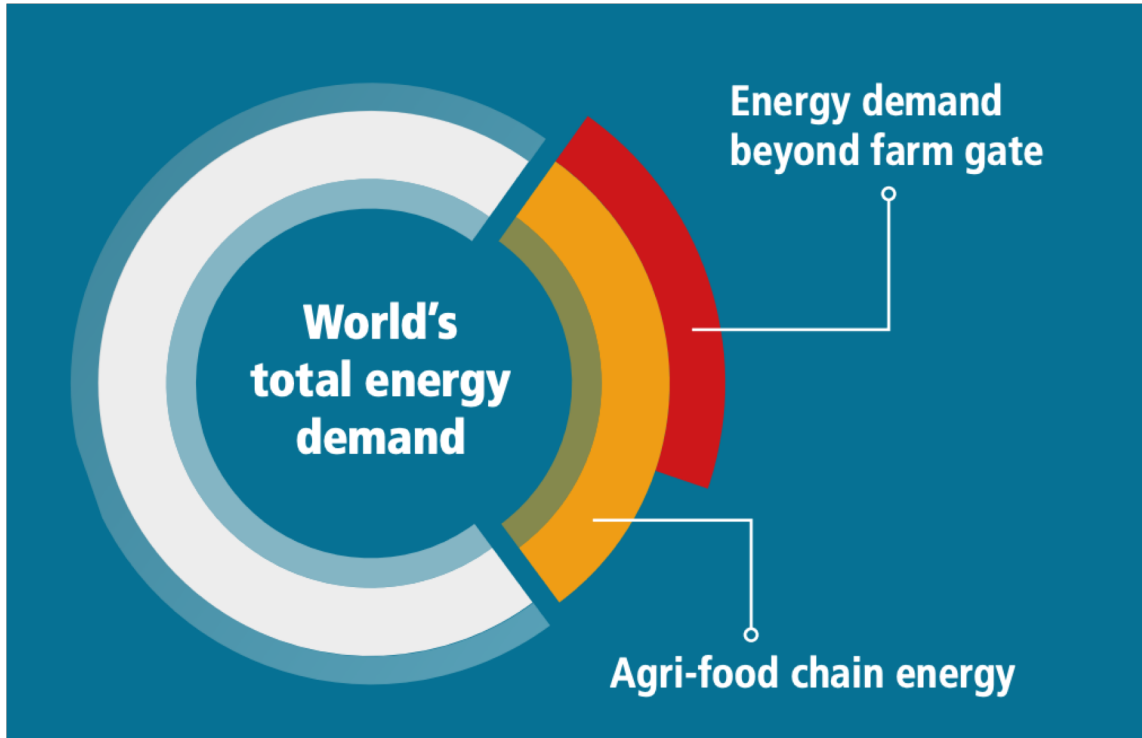
$\text{H}_2\text{O} = \text{Population} * \text{Food} * \text{H}_2\text{O/unit of food}$

# TOTAL IMPACT

ENERGY: ~ 20% of total energy (data for the US)

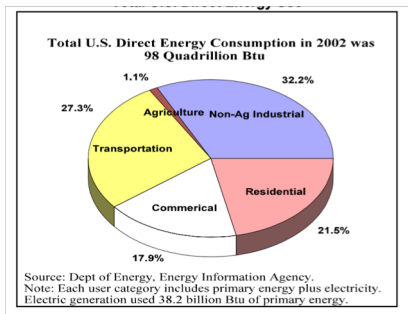


# ENERGY USE



# TOTAL IMPACT

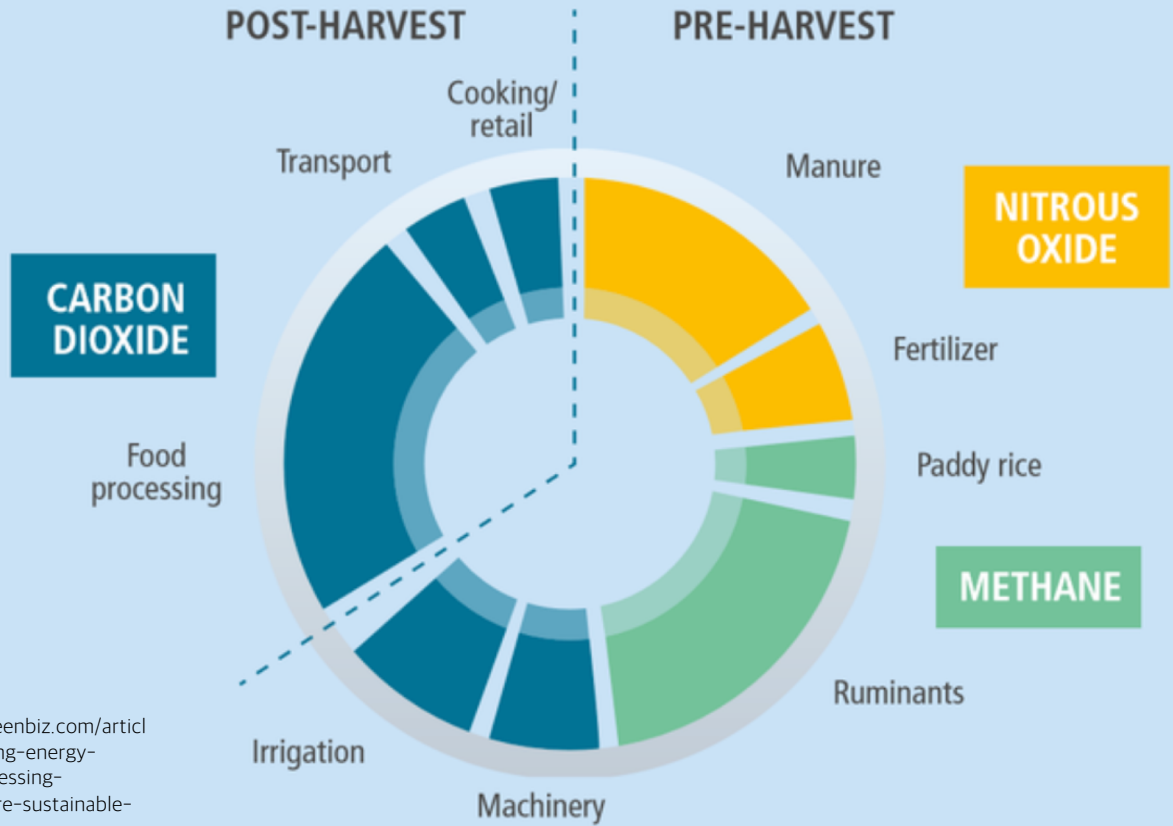
ENERGY: ~ 20% of total energy



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



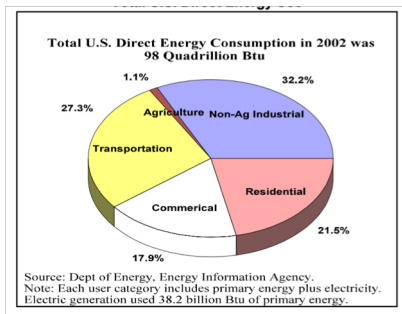
# GHG EMISSIONS



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

# TOTAL IMPACT

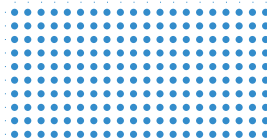
ENERGY: ~ 20% of total energy



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



WATER: 70% of total withdrawal (~ 4000 km<sup>3</sup>/y)



# TOTAL IMPACT

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$$\text{IMPACT} = \text{Population} * \text{Quantity} * \text{Intensity}$$

# REDUCING FOOD QUANTITY

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

## **1/3 of the food is wasted**

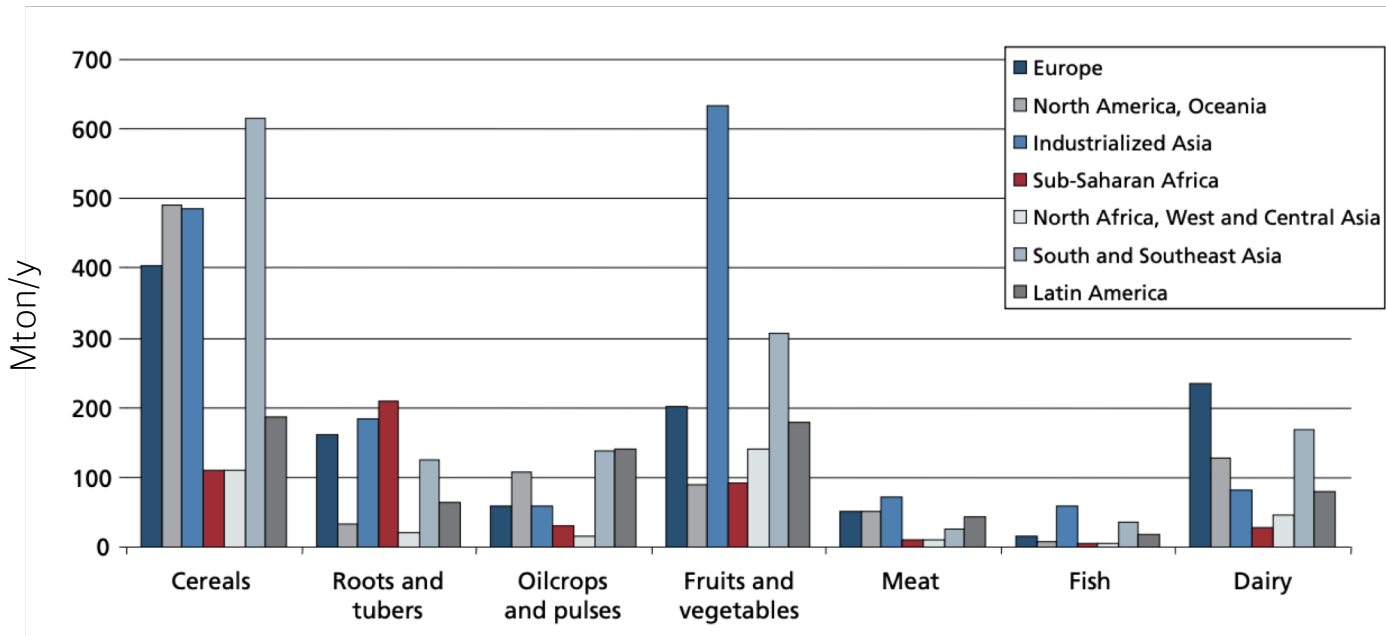
US: 1250day out of 3950 kcal/day available

## **Amount of food waste**

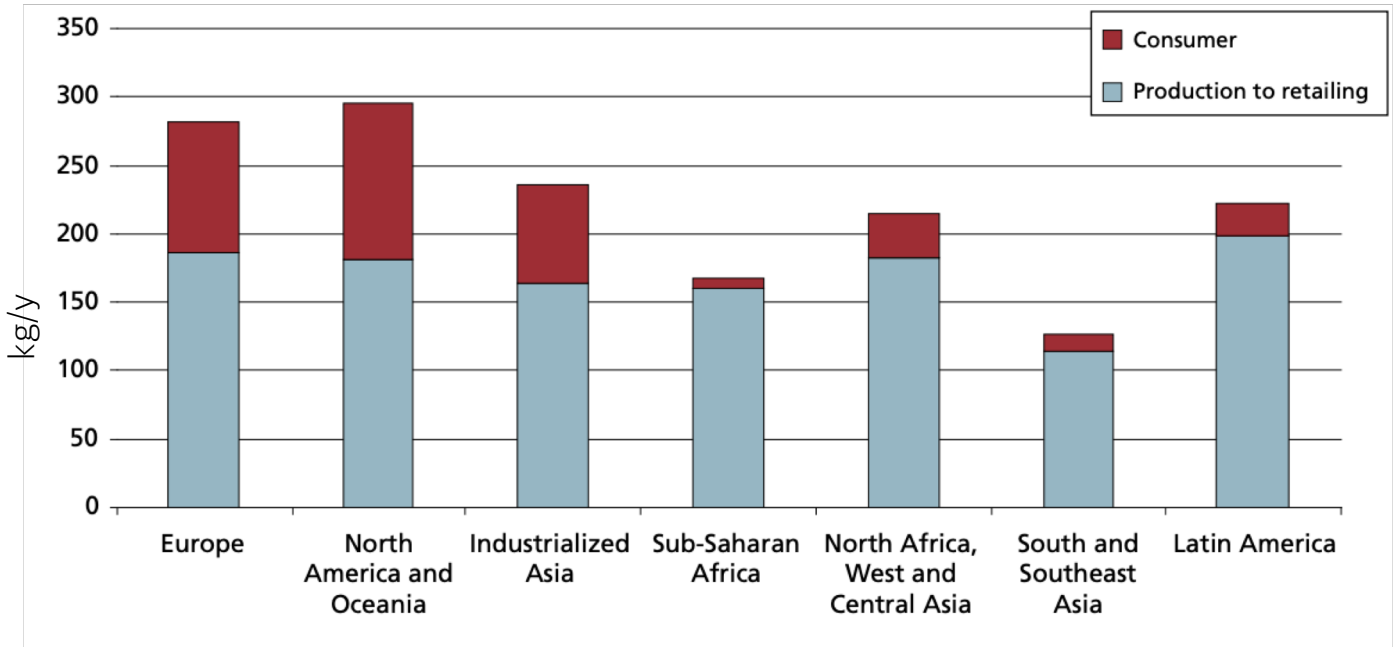
95-115 kg/year in Europe and US

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

# PRODUCTION VOLUME

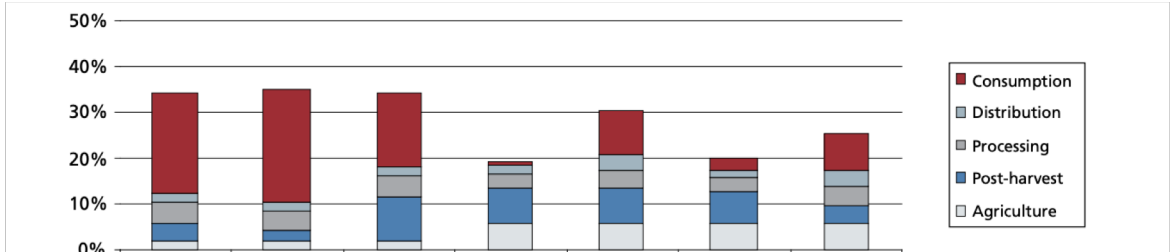


# FOOD WASTE

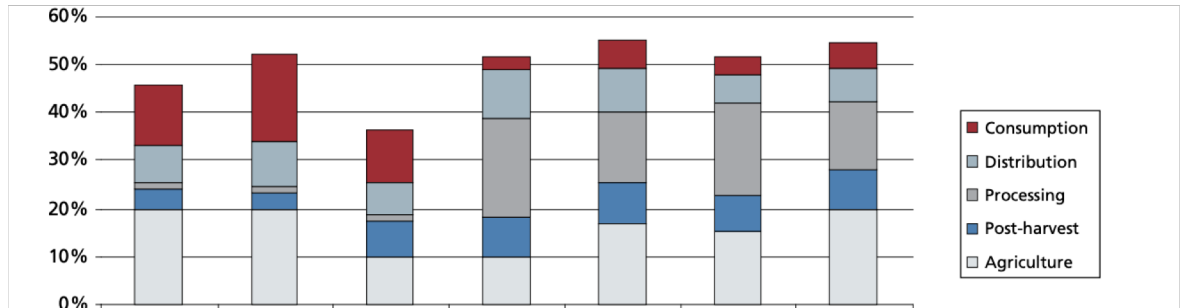


# REDUCING FOOD QUANTITY

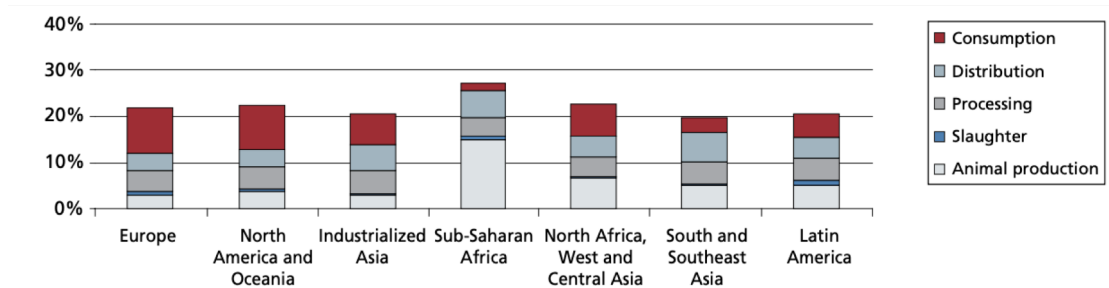
Crop



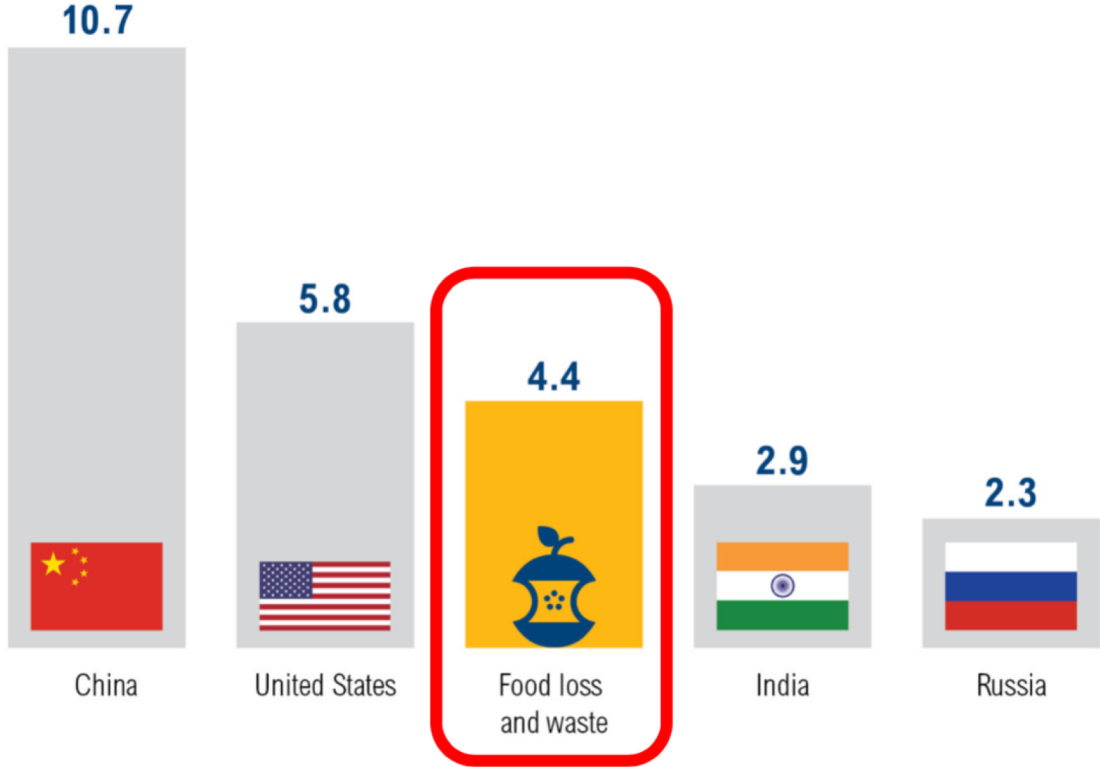
Fruit



Meat



# FOODWASTE EMISSION



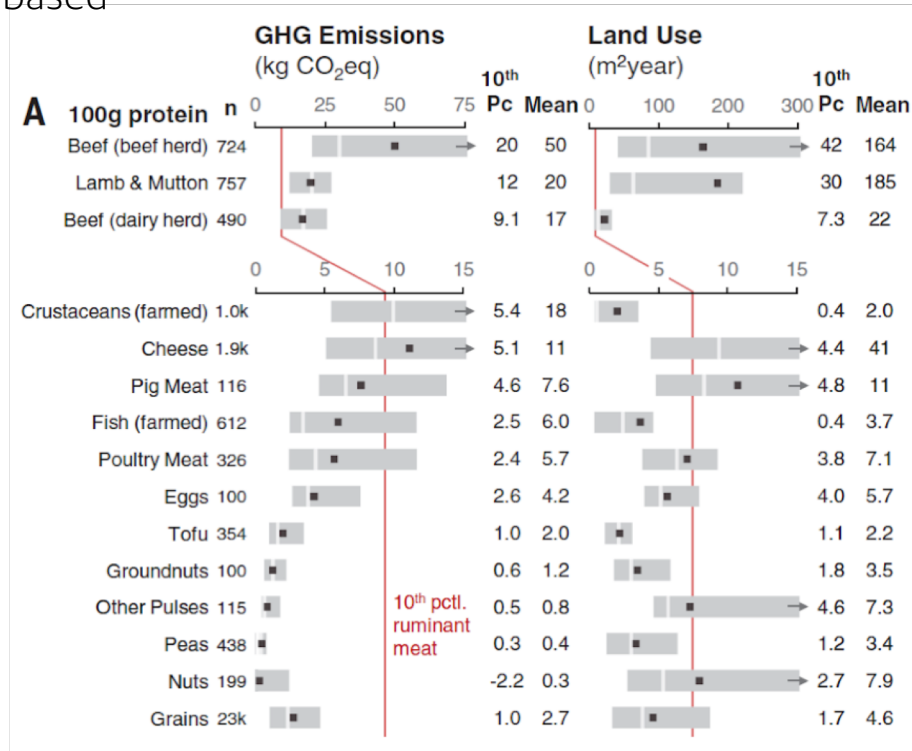
GT CO<sub>2</sub>E (2011/12)\*

# TOTAL IMPACT

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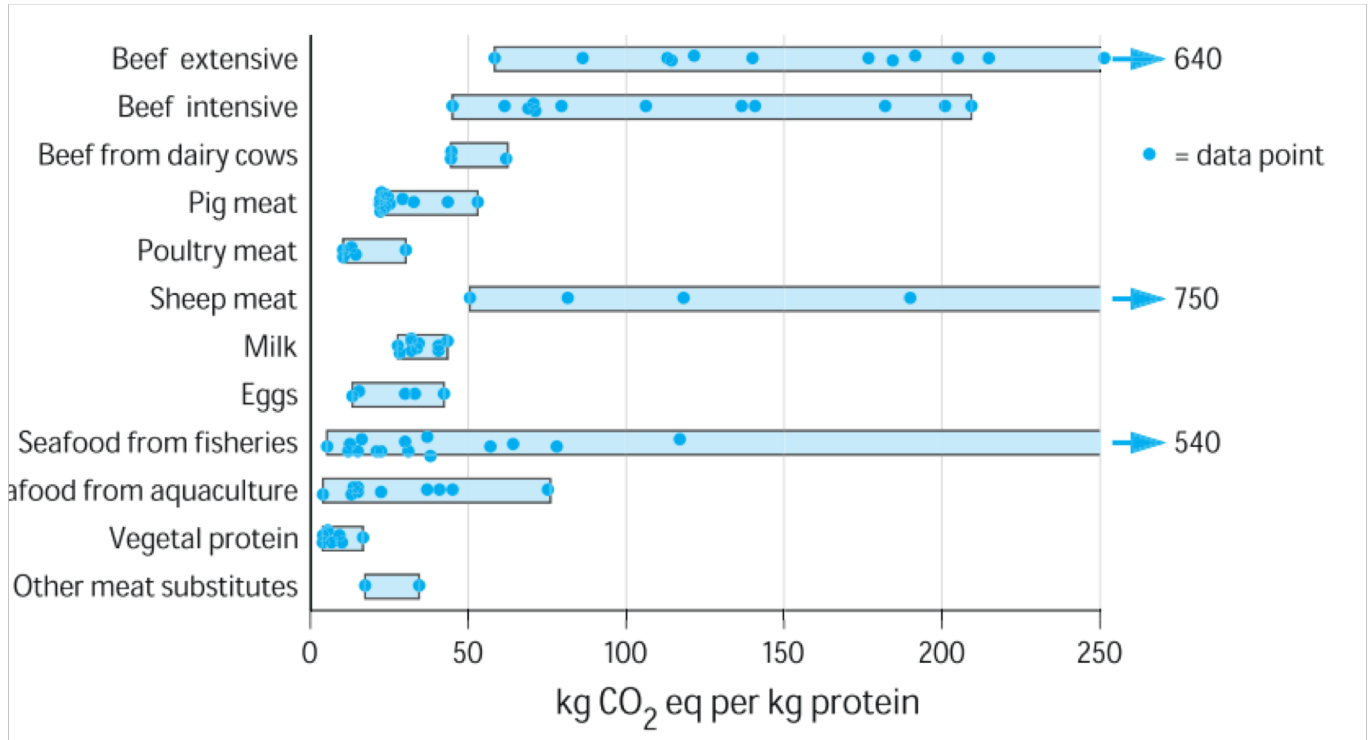
# EMISSION INTENSITY

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

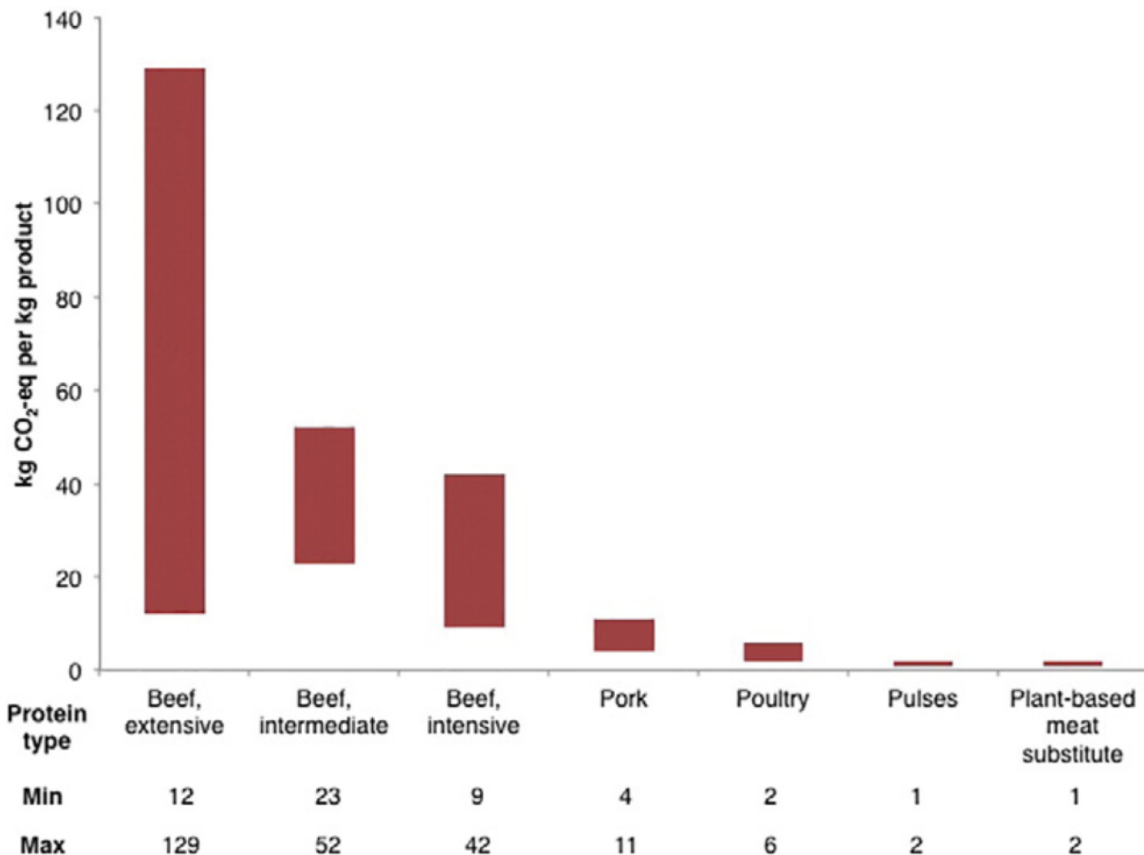


# EMISSION INTENSITY

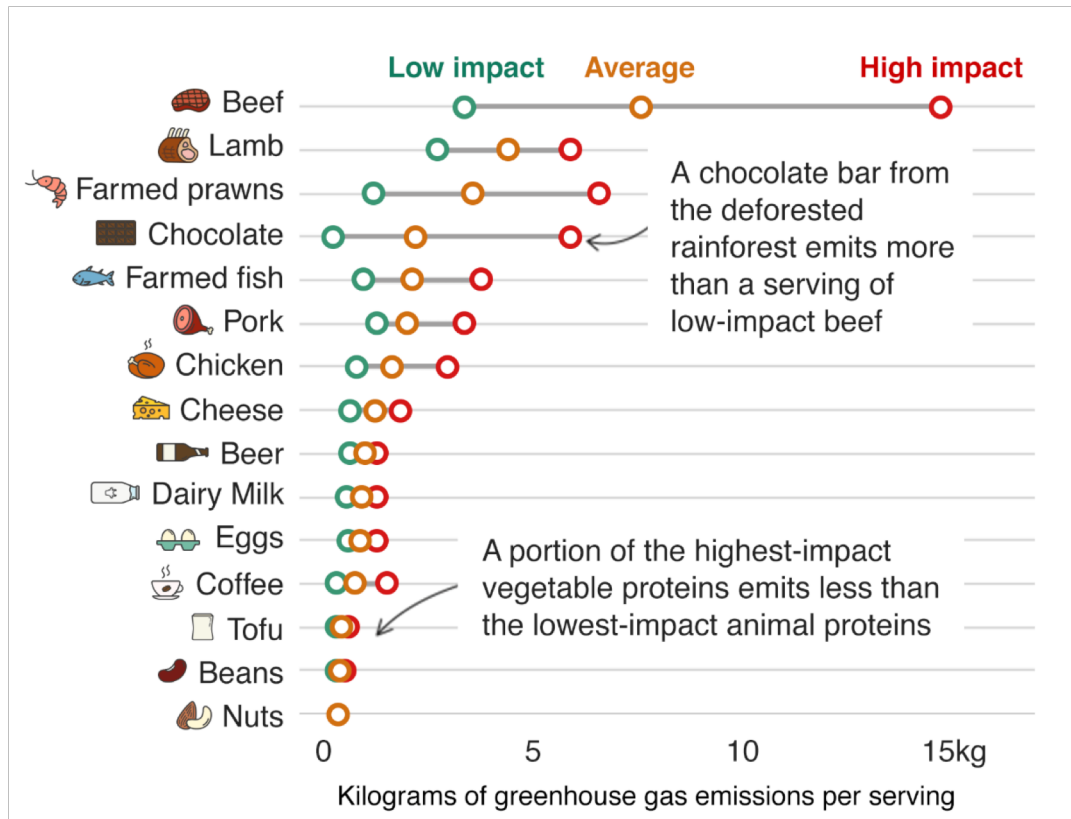
- Dataset: 30 LCA studies



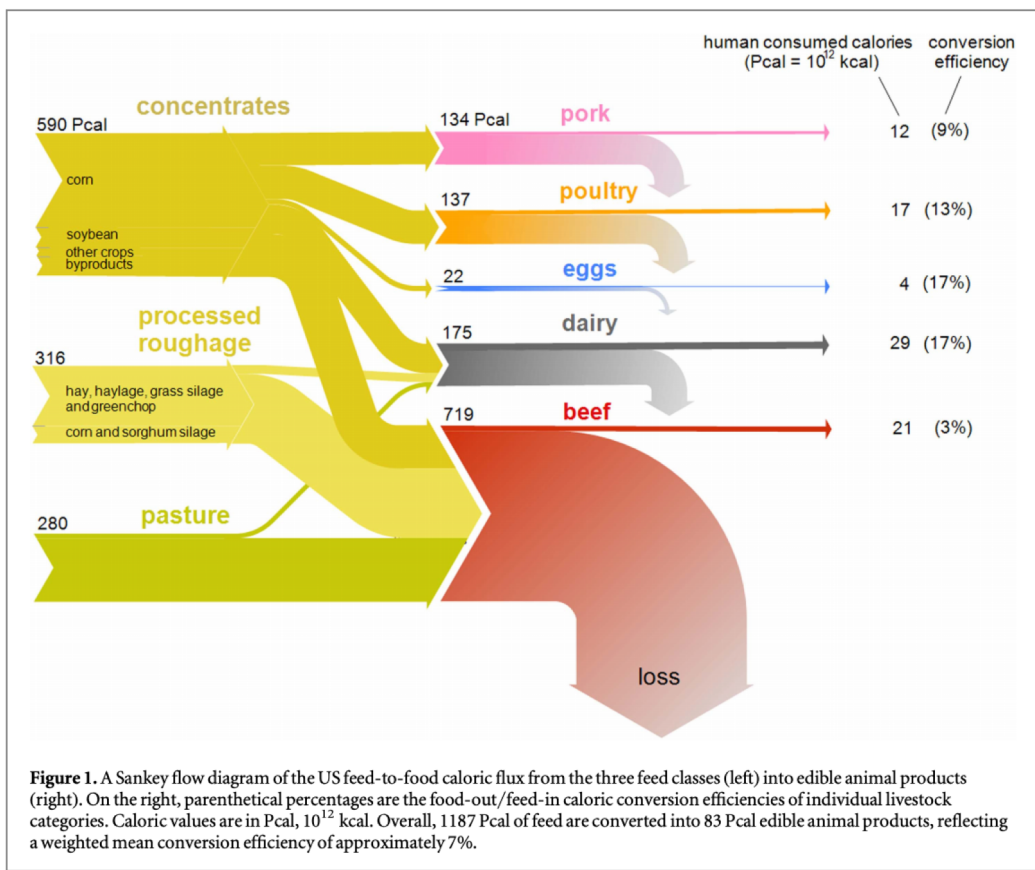
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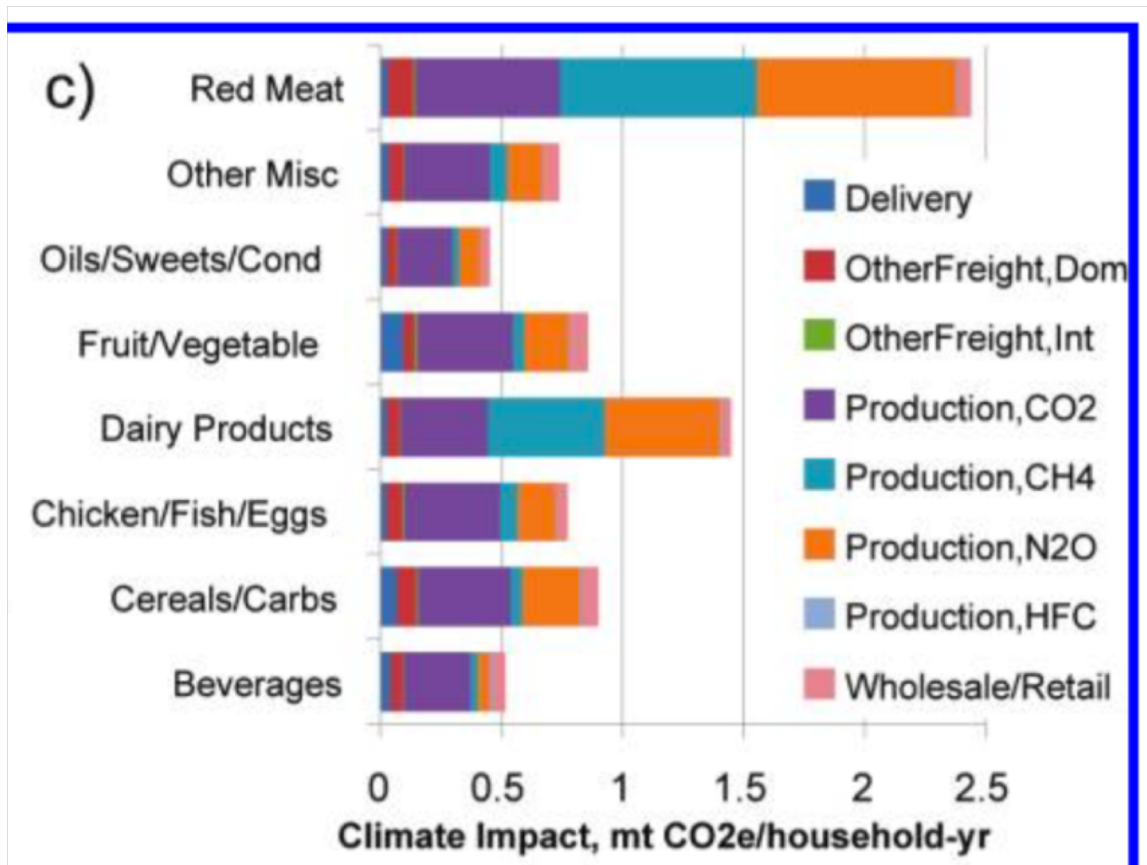
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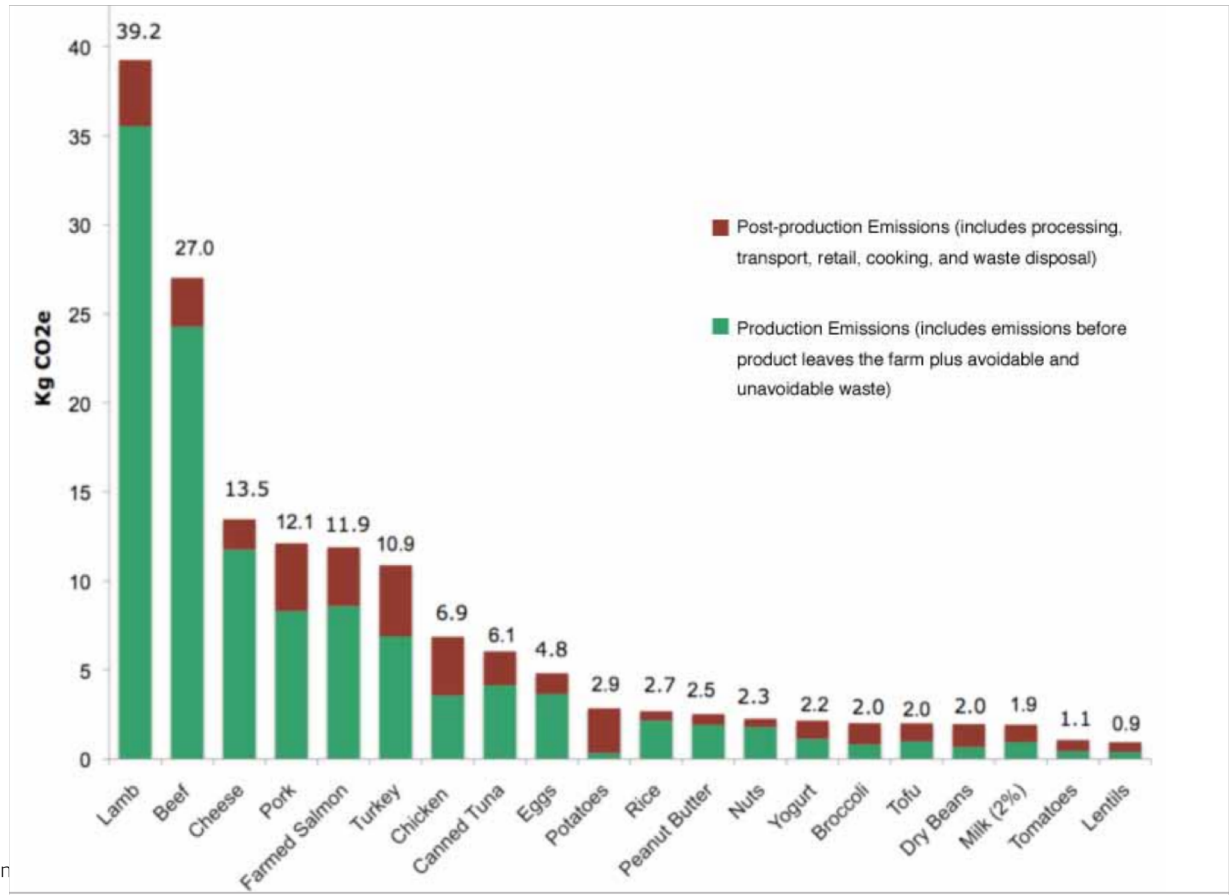
# INEFFICIENCY



# EMISSION INTENSITY (by sector)



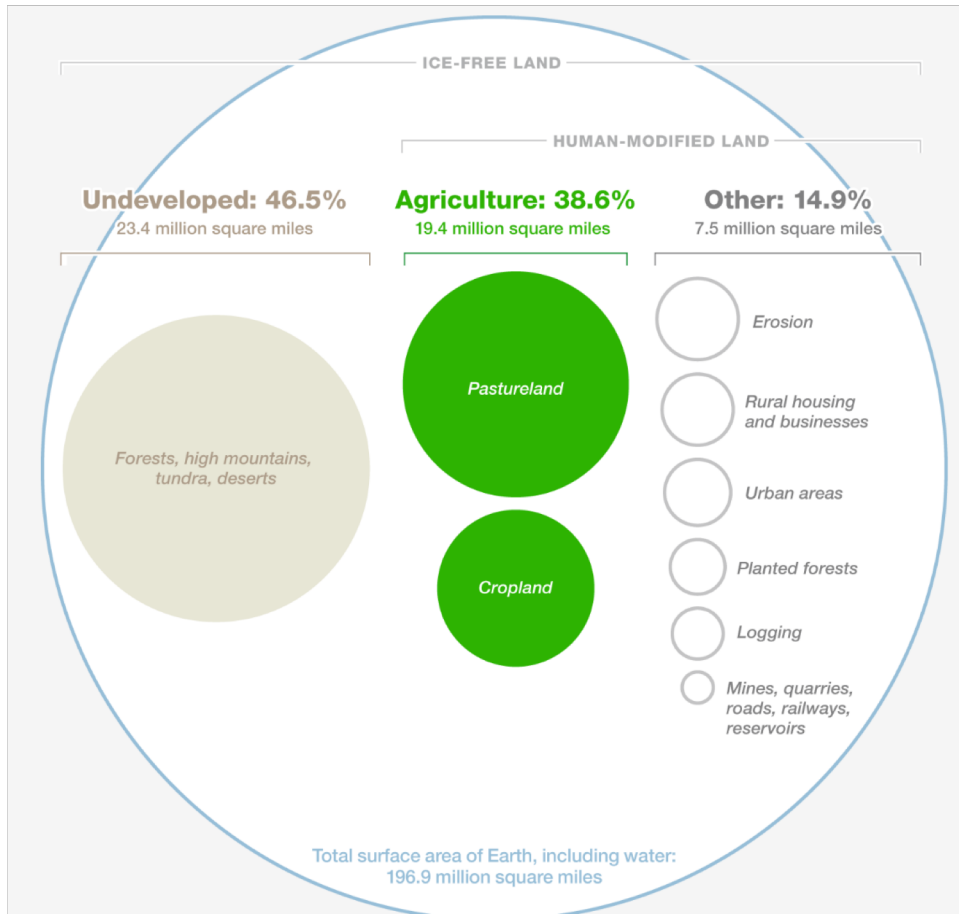
# EMISSION INTENSITY (by sector)



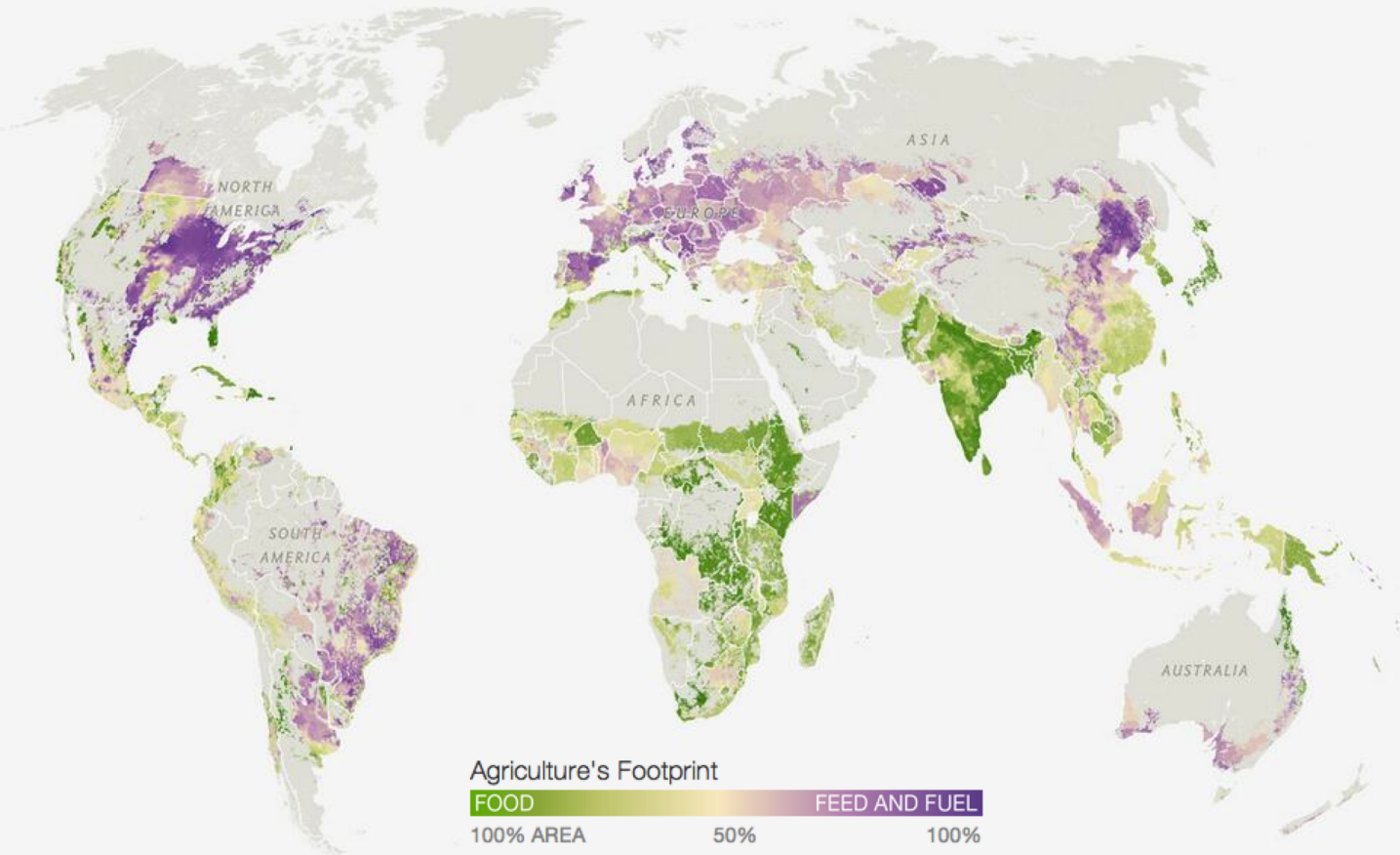
# TRANSPORT

	<b>MJ/t-km</b>	<b>t CO<sub>2</sub>e/t-km × 10<sup>6</sup></b>
inland water	0.3	21
rail	0.3	18
truck	2.7	180
air <sup>a</sup>	10.0	680 <sup>a</sup>
oil pipeline	0.2	16
gas pipeline	1.7	180
int. air <sup>a</sup>	10.0	680 <sup>a</sup>
int. water container	0.2	14
int. water bulk	0.2	11
int. water tanker	0.1	7

# LAND USE DILEMMA



# FOOD vs FEED/FUEL



# 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

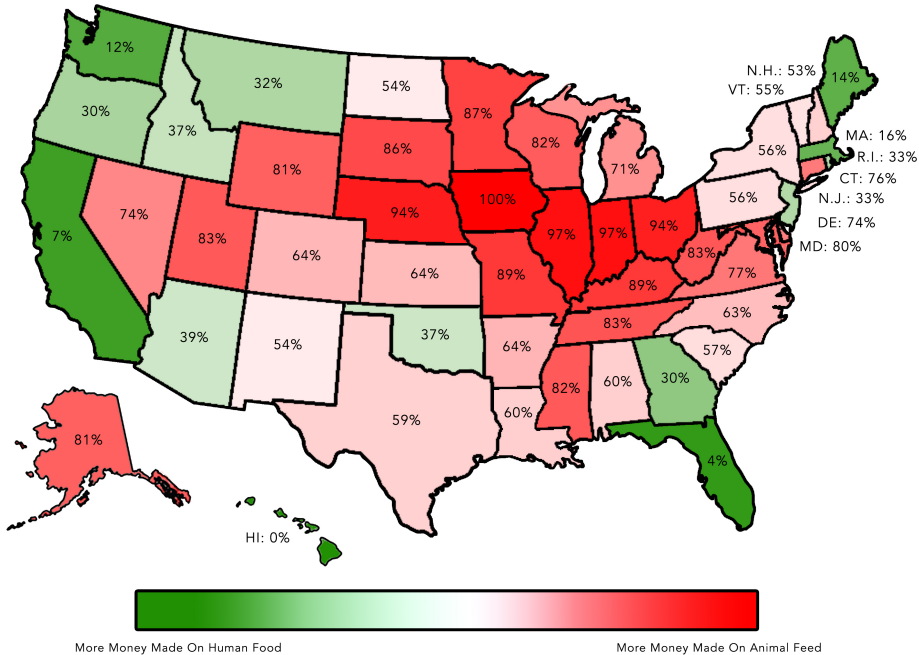
## US

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

# 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.

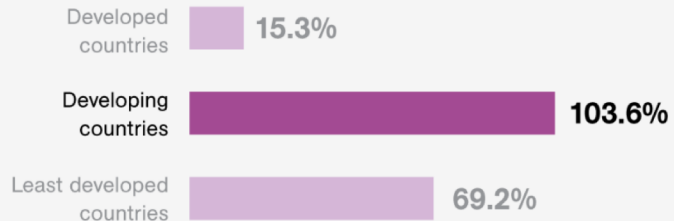
# FUTURE SCENARIO



*To feed that population, crop production will need to double.*

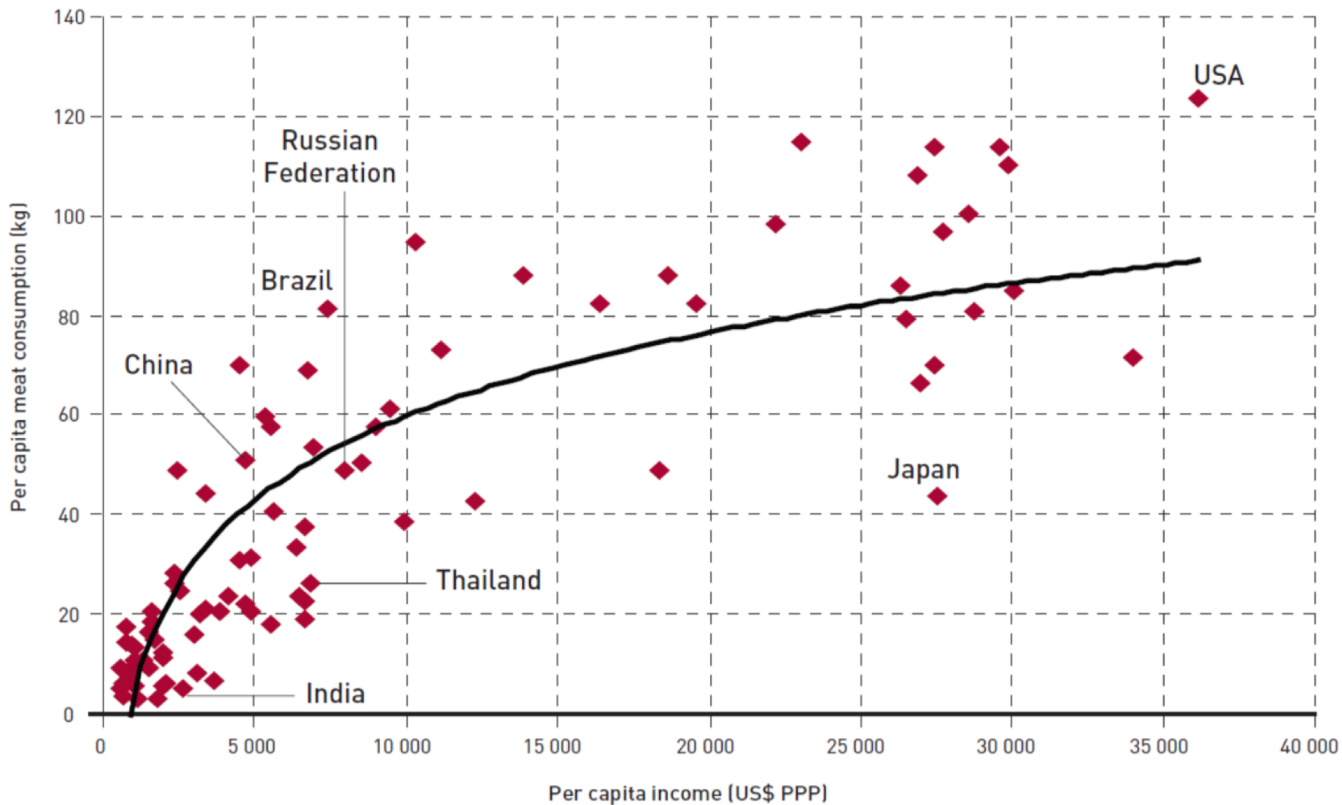


*Why? Production will have to far outpace population growth as the developing world grows prosperous enough to eat more meat.*



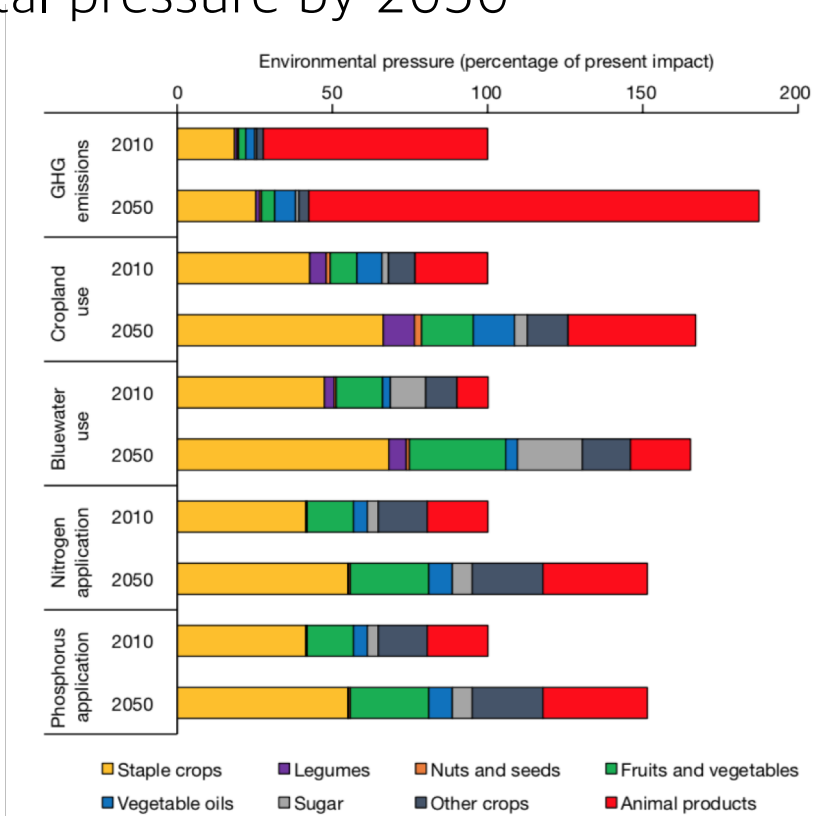
# FUTURE SCENARIO

## Meat consumption and per capita income - 2002

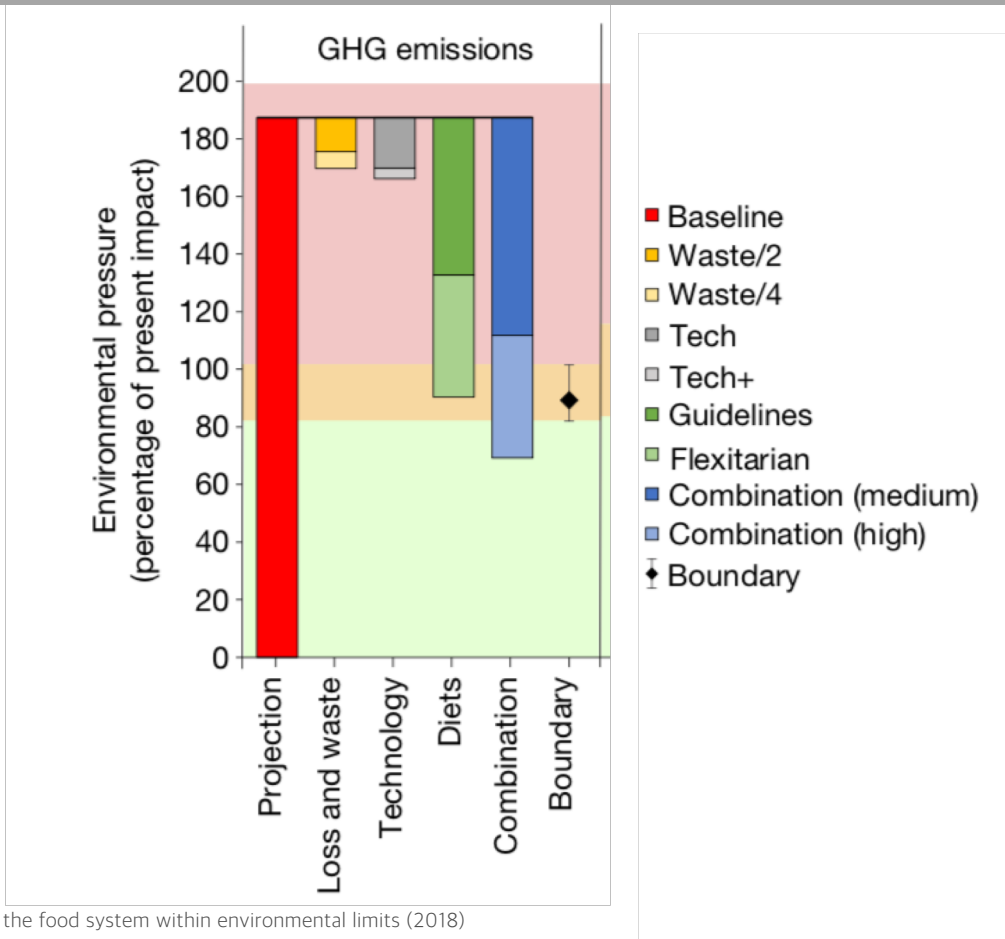


# FUTURE SCENARIO

## Environmental pressure by 2050

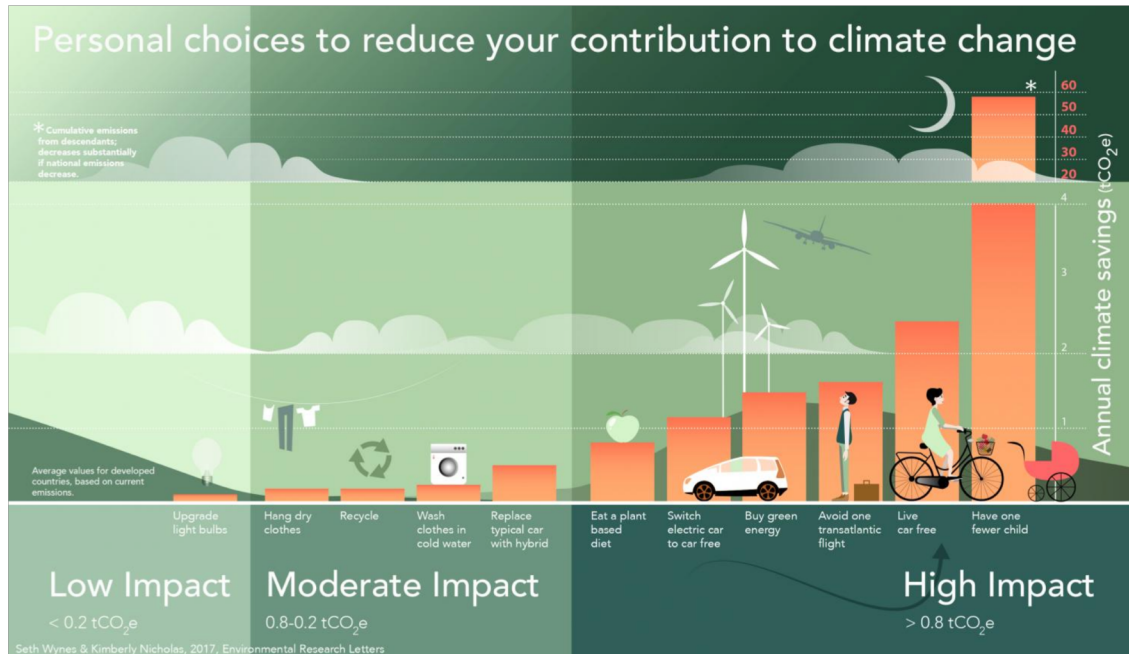


# FUTURE SCENARIO



# CONCLUSIONS

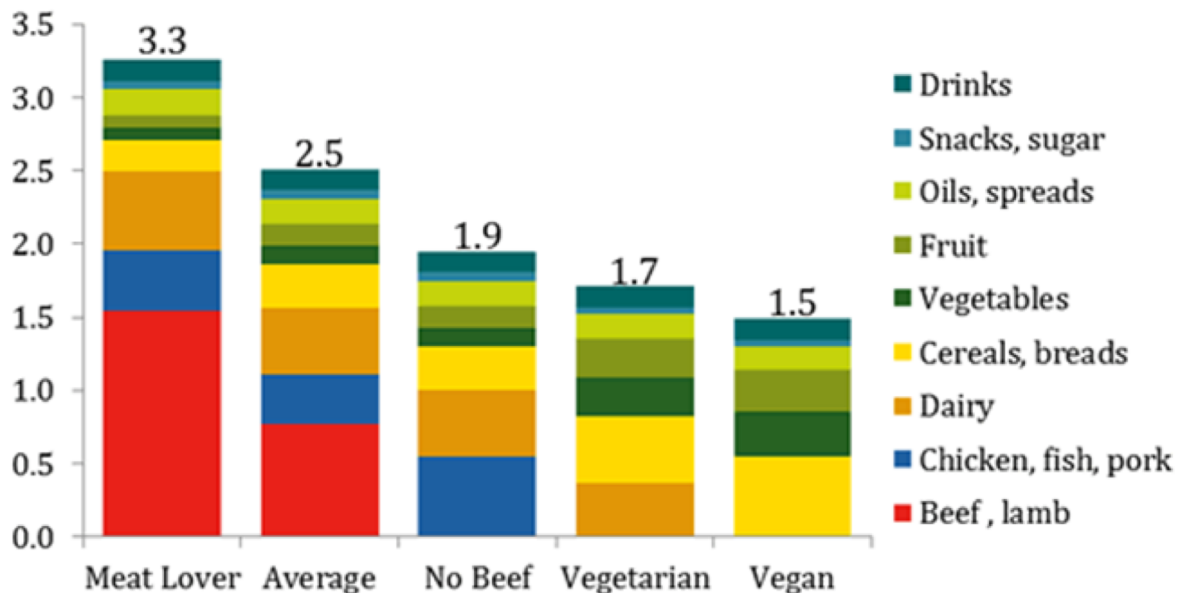
- Consume foods lower on the food chain
- Avoid energy-intensive production
- Avoid energy-intensive transportation



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

# BACK UP

## Foodprints by Diet Type: t CO<sub>2</sub>e/person

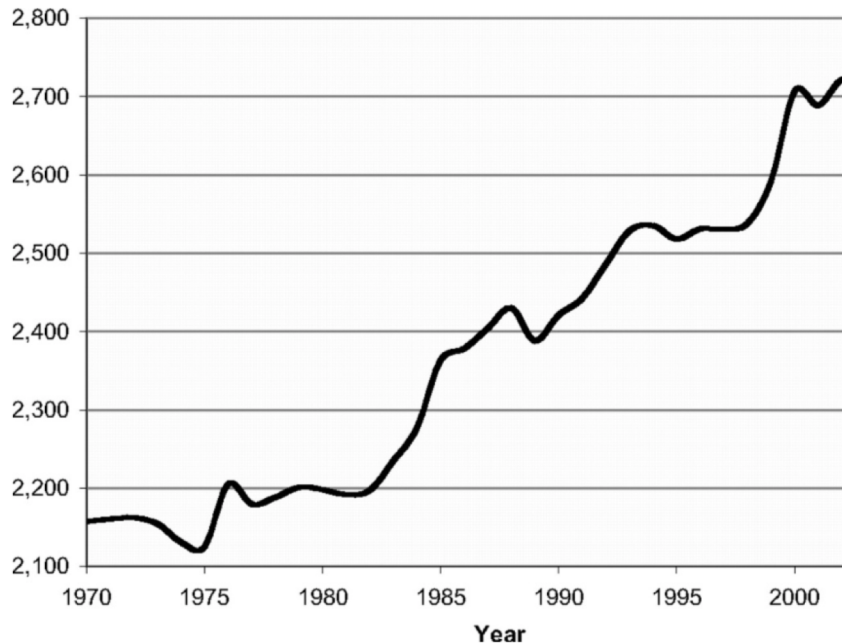


Note: All estimates based on average food production emissions for the US. Footprints include emissions from supply chain losses, consumer waste and consumption.. Each of the four example diets is based on 2,600 kcal of food consumed per day, which in the US equates to around 3,900 kcal of supplied food.

Sources: ERS/USDA, various LCA and EIO-LCA data

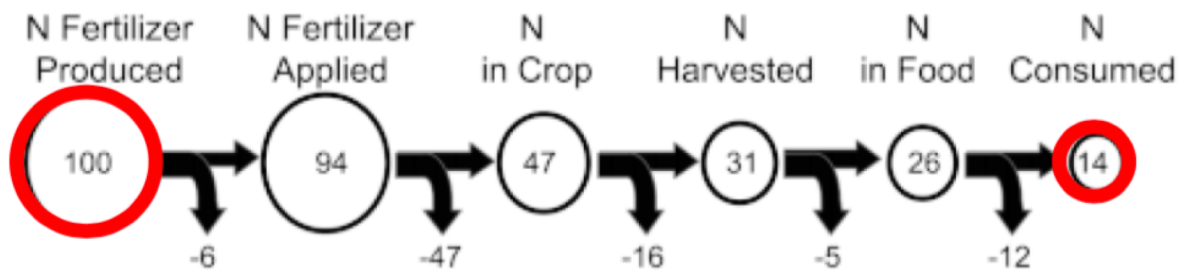
# Per capita daily caloric intake

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

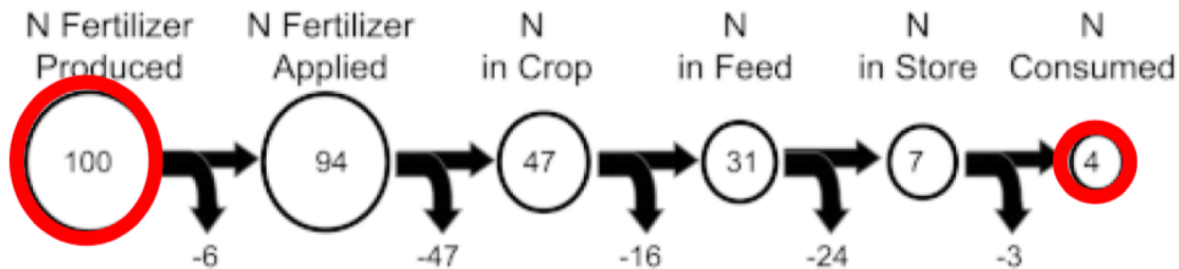


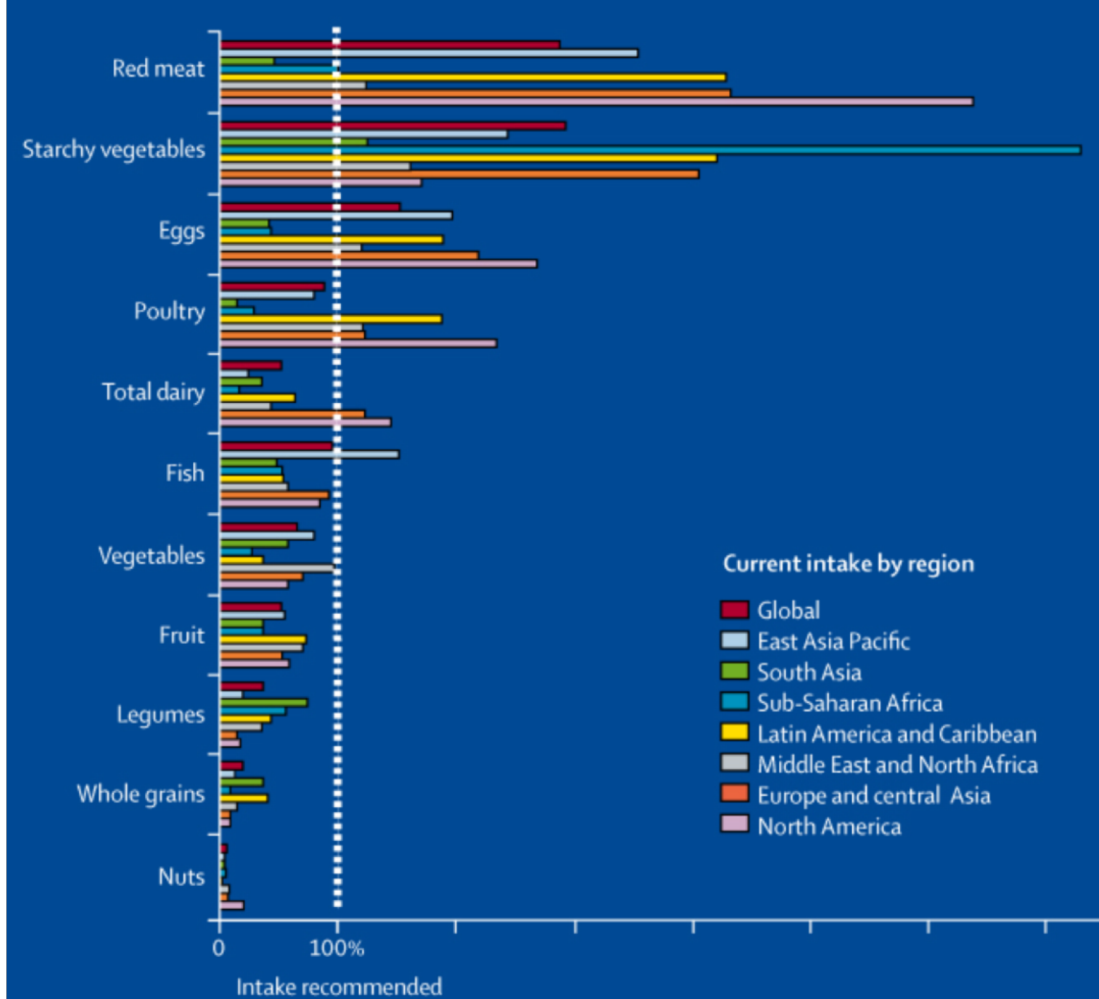
(White J S Am J Clin Nutr 2008;88:1716S-1721S)

a.

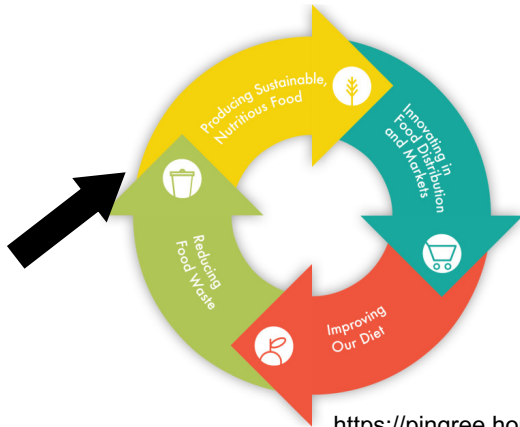


b.





# Reducing Food Waste



**EXCESSIVE**

**40%**  
OF ALL FOOD PRODUCED IN THE U.S. IS WASTED

**133 BILLION POUNDS**  
Food wasted per year. That represents 1,249 calories per person, per day.

**EXPENSIVE**

**\$161 BILLION**  
Uneaten food at retailers, restaurants, and homes costs \$161 billion annually

**\$1,500**  
Per capita, this amounts to over \$1,500 for a family of four

**ENVIRONMENTALLY HARMFUL**

Food makes up 20% of landfill weight—the single largest municipal waste source

**CH<sub>4</sub>** CO<sub>2</sub>  
The methane released by food is a greenhouse gas 21 times more powerful than carbon dioxide

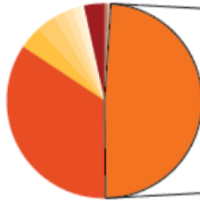
**AN OPPORTUNITY**

Diverting 15% of the food that currently goes to waste would be enough to cut the number of food insecure Americans in half

Food waste can be composted into sustainable soil additives or be used to generate electricity

Encouraging institutions to purchase so-called "ugly" produce would help farmers find new markets for healthy products that currently go to waste

### Food system emissions



### Direct agricultural emissions



#### PREPRODUCTION

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

#### PRODUCTION

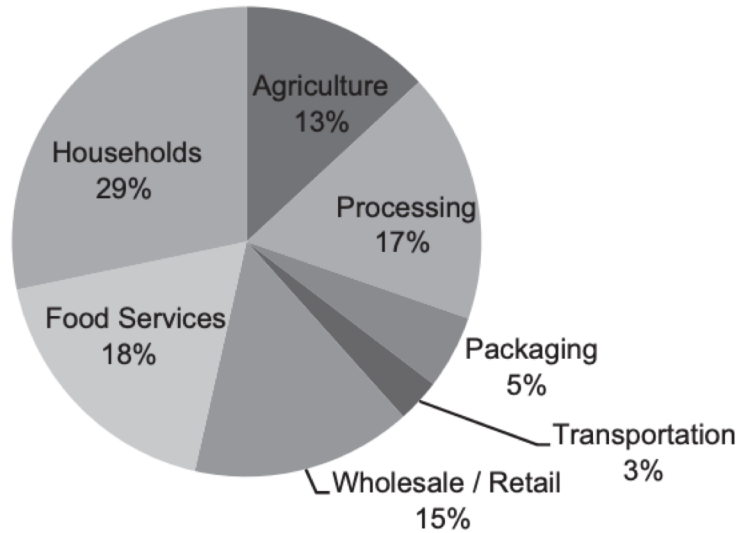
- Direct emissions **48.5%**
- Indirect emissions (deforestation) **35%**

#### 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%**

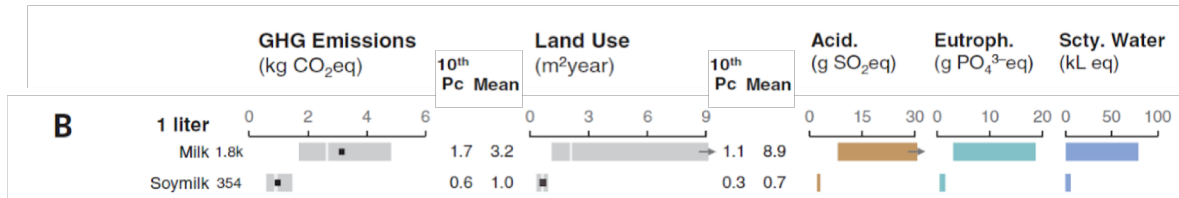
- Agricultural soils **32%**
- Enteric fermentation **31%**
- Other emissions **19%**
- Rice cultivation **12%**
- Manure management **6%**

Total = 14,760 PJ

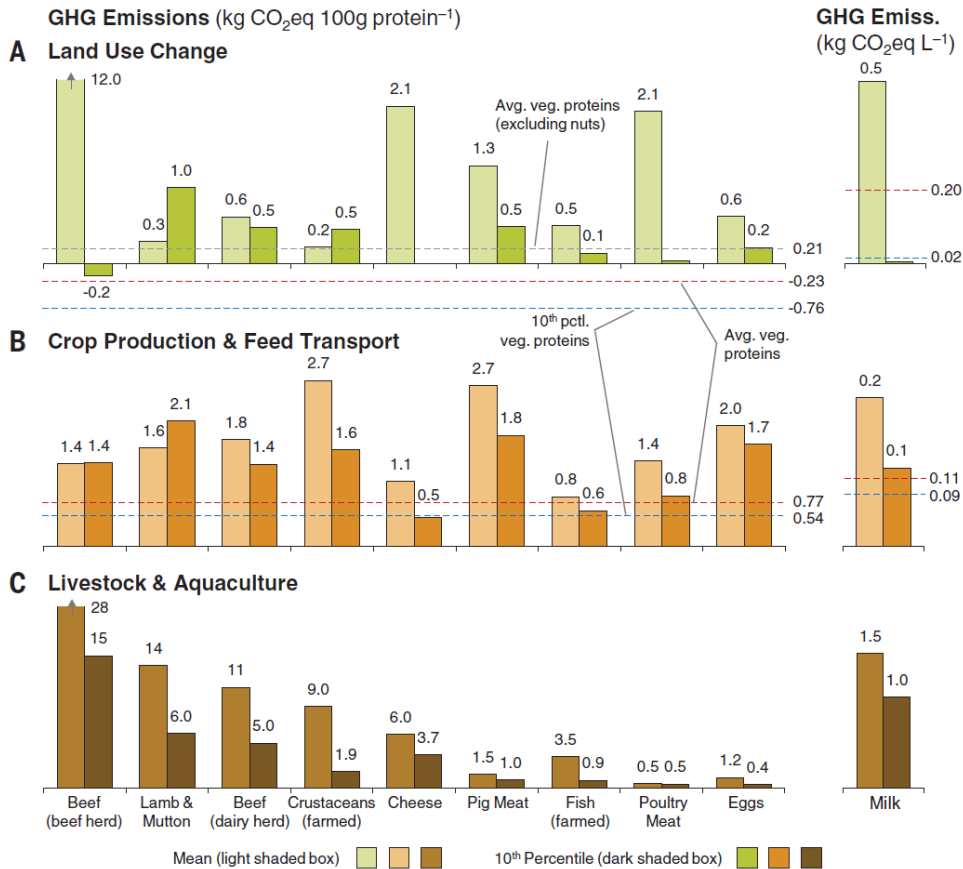


# EMISSION INTENSITY


## Relative impacts of milk



# EMISSION INTENSITY (by sector)



# Harvard food system initiatives

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[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*

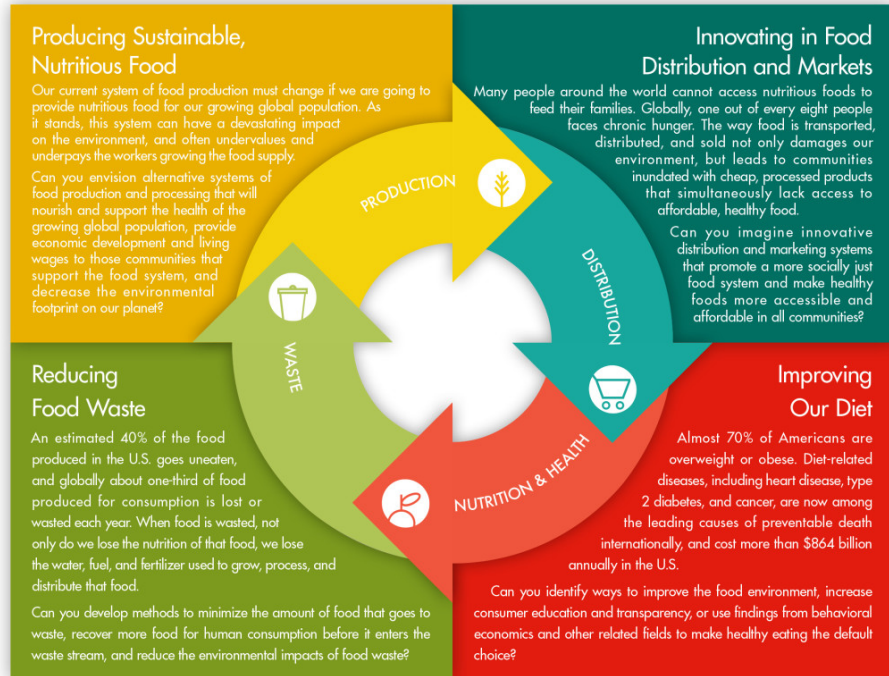
### What is Food Better?

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:



# Harvard food system initiatives

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



# Harvard food system initiatives



- 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.



# Harvard food system initiatives

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## Plant-based eating guide

Harvard College student and Resource Program Efficiency Representative Meaghan Townsend (Class of 2021) created this simple guide to start a conversation about sustainable eating to encourage her peers to explore plant-based diets at Harvard. It was designed to empower students who are interested in pursuing a plant-based diet and to support those who already are. The guide was supported by the Harvard Office for Sustainability and Harvard T.H. Chan School of Public Health.

SHARE THIS

### HEALTH BENEFITS

A **healthful, plant-based diet** has been associated with:

- Lower risk of cardiovascular disease and stroke
- Lower risk of certain cancers
- Lower blood pressure
- Lower risk of cataracts and macular degeneration
- Lower cholesterol
- Lower risk of digestive problems
- More stable blood sugar, which may help reduce appetite

### ENVIRONMENTAL BENEFITS

If all 7,000 Harvard undergraduates went without meat just **one day a week** for a year, we would collectively save:

1.2 billion lbs of water	1.6 million animal lives
2.6 million acres of land	7.3 million gallons of gas
5.3 million dollars	1.8 million lbs of crops that would otherwise be lost to livestock
1.8 million lbs of carbon	10.7 million lbs of animal waste

These savings have tremendous implications for global food insecurity. The crops fed to livestock constitute more than **TWICE** enough food to feed the 1.4 billion people currently living in abject poverty. With world population projected to reach 9.7 billion by 2050, it will become increasingly important that we take advantage of methods—like eating plant-based diets—of producing and consuming food more efficiently.

See parentheses page for sources.

### BUILDING YOUR PLATE

Based on the best available research on diet and health, Harvard's Healthy Eating Plate emphasizes a variety of high-quality, plant-based foods.

**HEALTHY EATING PLATE**

**VEGETABLES** (Half the plate): The more, the better. Aim for a variety of colors and textures. Fill at least half the plate with vegetables. Don't forget starchy vegetables like potatoes, corn, and beans.

**GRAINS** (Quarter the plate): Choose whole grains. Aim for at least 48 grams of whole grains a day. Limit refined grains like white bread, white rice, and pasta.

**PROTEIN** (Quarter the plate): Choose fish, beans, tofu, and other plant-based proteins. Limit red meat, poultry, and eggs.

**FRUITS** (Quarter the plate): Choose fresh, frozen, or canned (without added sugar) fruits. Limit fruit juices.

**DAIRY/PROTEIN** (Side): Choose low-fat dairy products like milk, yogurt, and cheese. Limit high-fat dairy products.

**WATER** (8 glasses a day): Drink water, tea, or coffee with little or no sugar. Limit sugary drinks.

**SAVING TIP:** Use a variety of oils like olive, canola, and avocado. Limit butter and margarine.

**SAVING TIP:** Limit sodium. Choose low-sodium products. Limit processed meats like hot dogs, deli meats, and canned soups.

**SAVING TIP:** Limit added sugars. Choose natural sweeteners like fruit. Limit sugary drinks.

**SAVING TIP:** Limit alcohol. If you drink, limit to one drink a day for women and two for men.

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