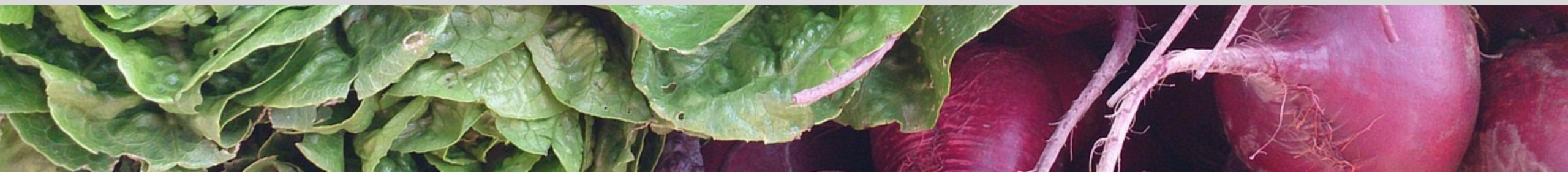




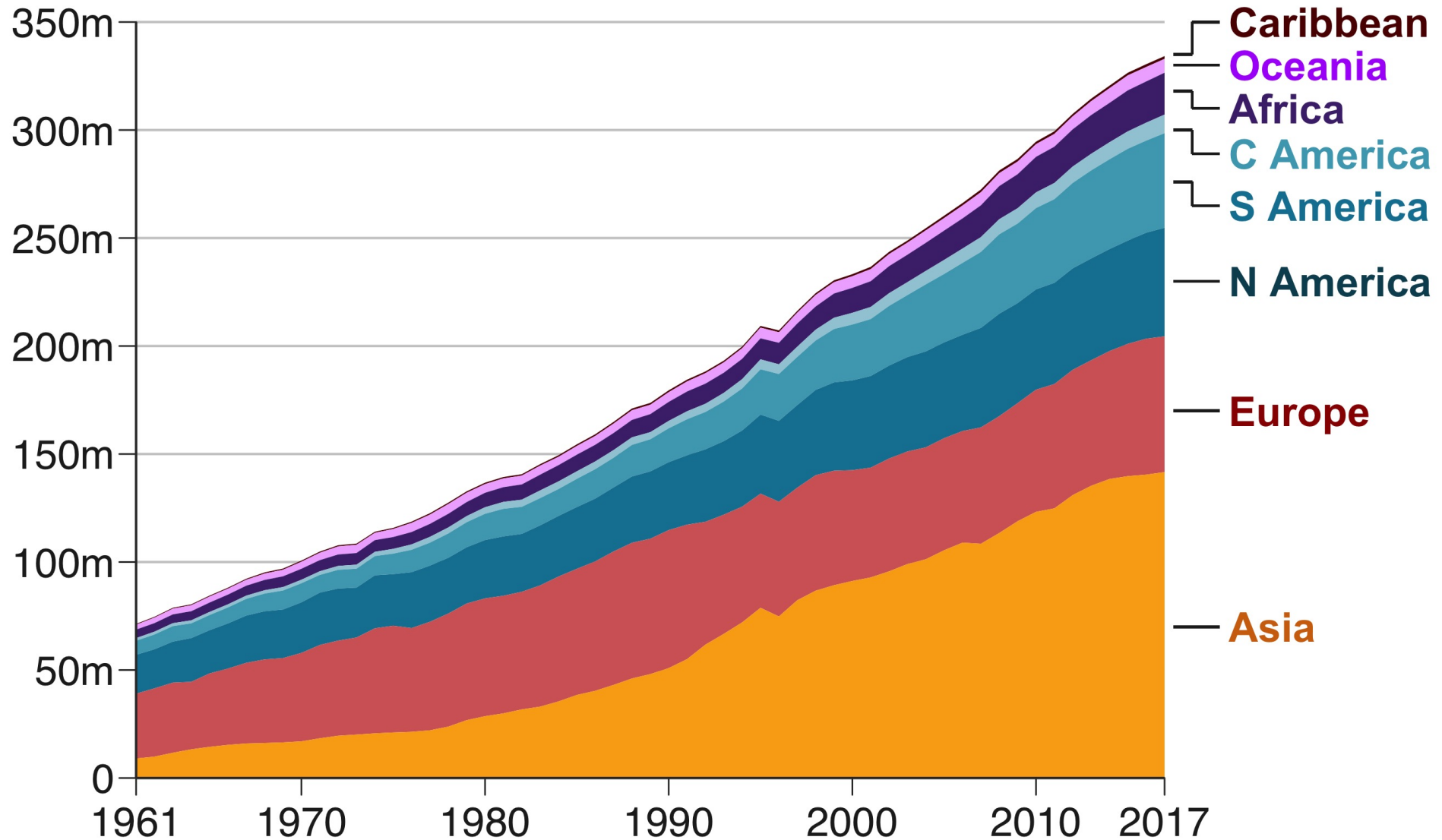
Healthy dietary patterns to mitigate climate change

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Meat production by region

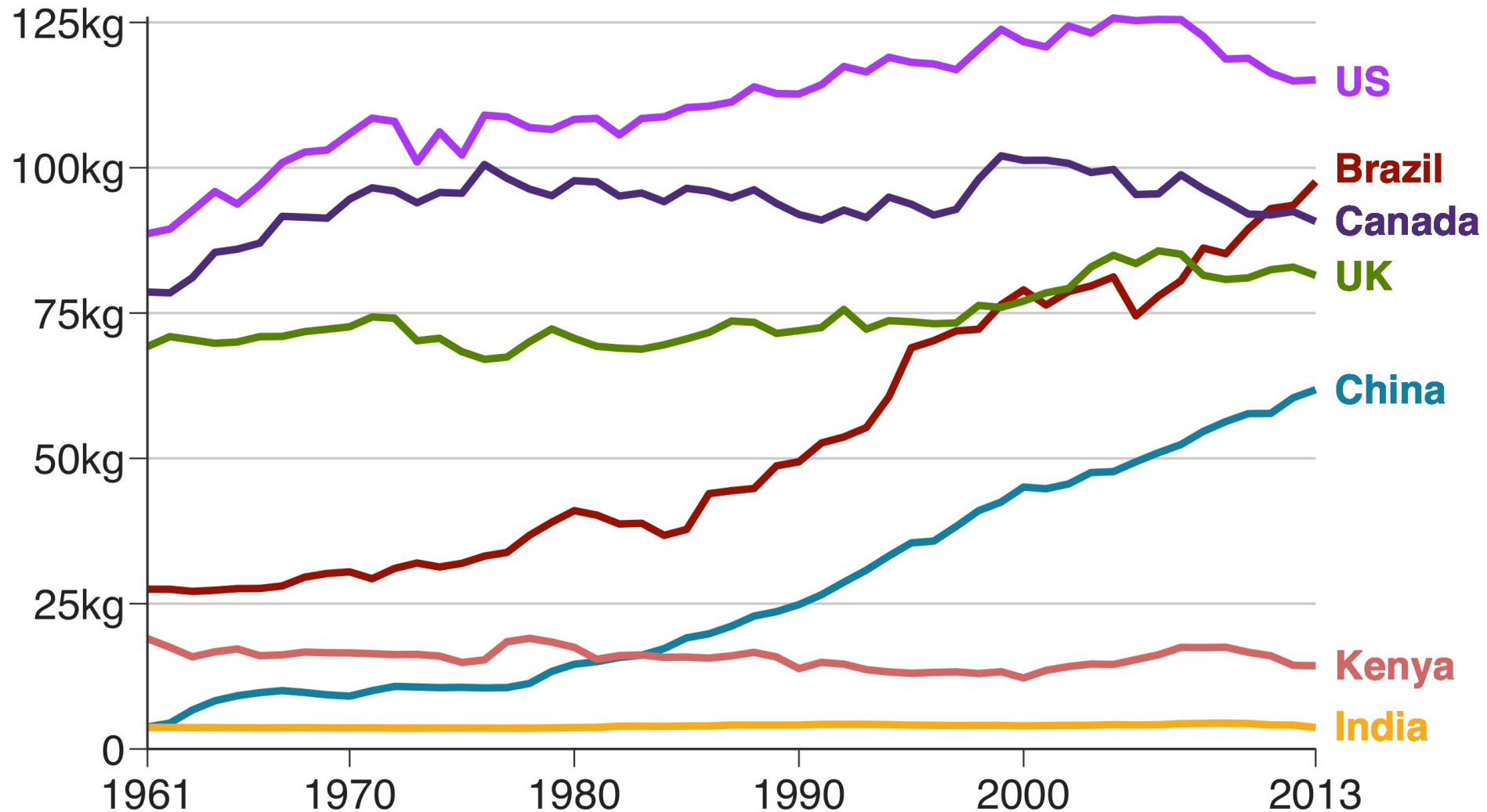
Annual production, in tonnes



Source: UN Food and Agriculture Organization / Our World in Data

Meat consumption by selected country

Average annual consumption per person



Source: UN Food and Agriculture Organization / Our World in Data

The Impact of Food Production on the Environment

- Contributes approximately 30% of global greenhouse gas emissions, and the livestock sector alone represents almost half (14.5%) of these emissions
- Occupies about 40% of global land
- Uses 70% of freshwater
- Is the largest factor threatening species with extinction
- Has led to a majority (~60%) of the world fish stocks to be fully fished or overfished (33%) – only 7% are underfished

RELATIVE GREENHOUSE-GAS EMISSIONS ASSOCIATED WITH SEVERAL COMMON PROTEIN SOURCES

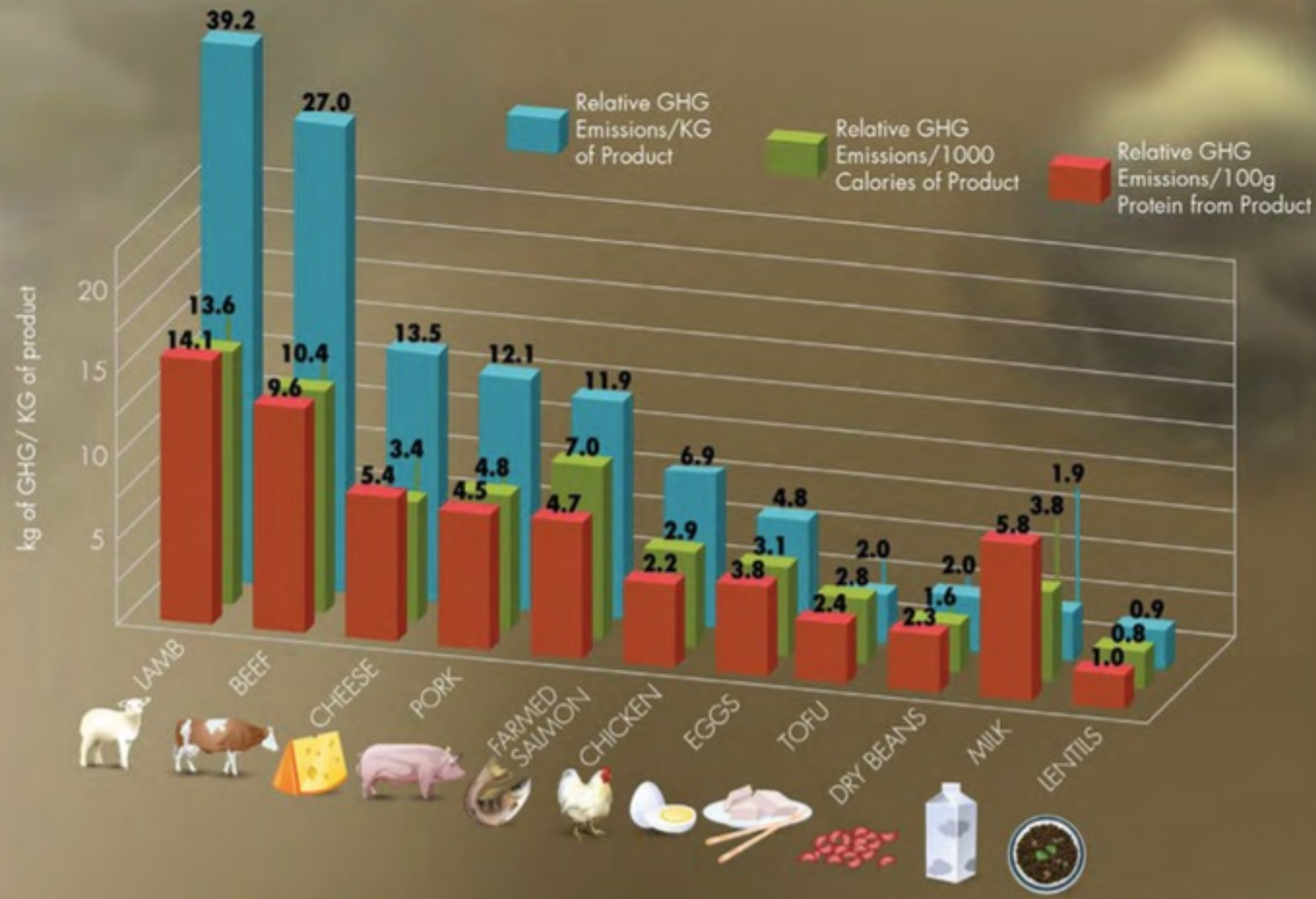
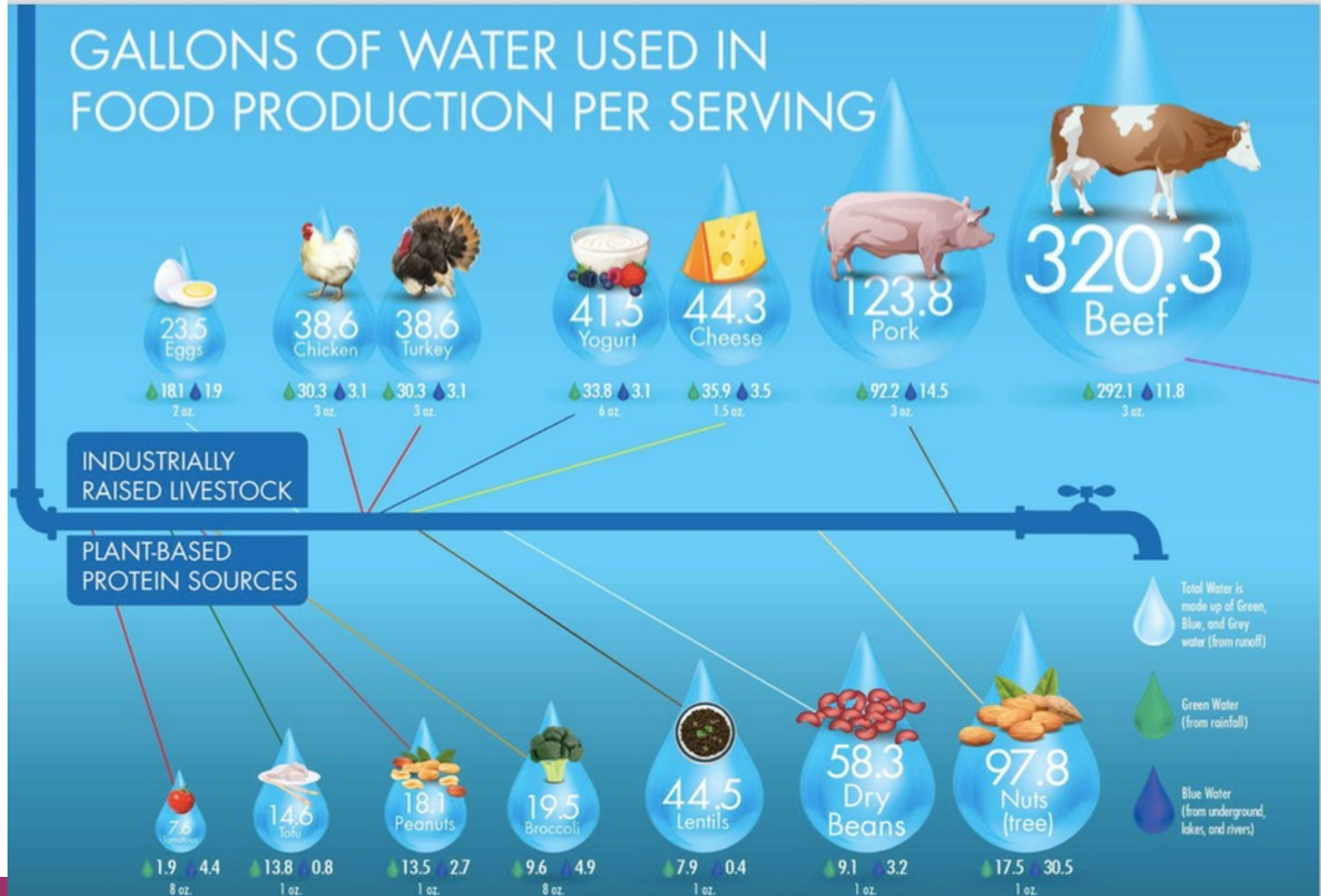


Table 1 illustrates the greenhouse-gas emissions associated with several common protein sources and is a good indicator of environmental impact including energy and chemical use, soil management, and mechanical irrigation. Both public health and the environment will improve if restaurants decrease the amount of red meat on menus and replace it with alternative protein sources.

GALLONS OF WATER USED IN FOOD PRODUCTION PER SERVING



Source Data: m3/ton in Water Footprint Network Water Statistics Table (Animals, Crops) for the U.S.
 Sources: T. Harter, 2015, Changing Tastes, 2015 and M.M. Mekonnen and A.Y. Hoekstra, "The Green, Blue and Grey Water Footprint of Crops and Derived Crop Products," and "The Green, Blue and Grey Water Footprint of Farm Animals and Animal Products," Value of Water Research Report Series No. 47 and 48, UNESCO-IHE, Delft, the Netherlands, 2010.

From: **Red Meat Consumption and Mortality: Results From 2 Prospective Cohort Studies**

Arch Intern Med. 2012;172(7):555-563. doi:10.1001/archinternmed.2011.2287

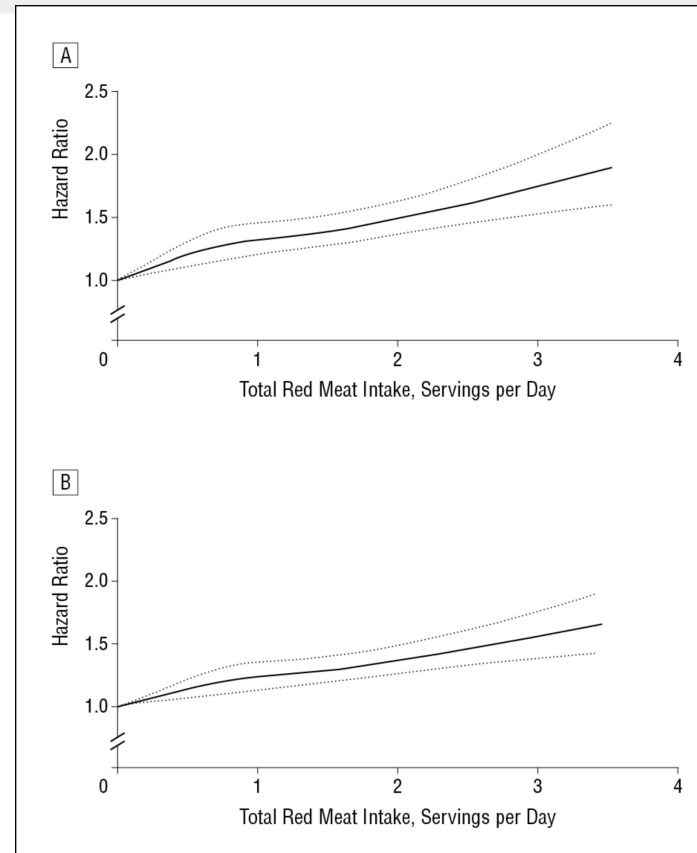


Figure 1. Dose-response relationship between red meat intake and risk of all-cause mortality in the Health Professionals Follow-up Study (A) and the Nurses' Health Study (B). fruits, and vegetables, all in quintiles. Broken lines represent 95% CI.



IARC Monographs evaluate consumption of red meat and processed meat

Processed meat was classified as carcinogenic to humans (Group 1), based on sufficient evidence in humans that the consumption of processed meat causes colorectal cancer.

The consumption of red meat was classified as probably carcinogenic to humans (Group 2A).

Dietary protein types and sources

Animal Protein

- “Complete” protein
- Higher concentration of protein

Sources:

- Meat
- Poultry
- Eggs
- Dairy
- Fish



vs.

Vegetable Protein

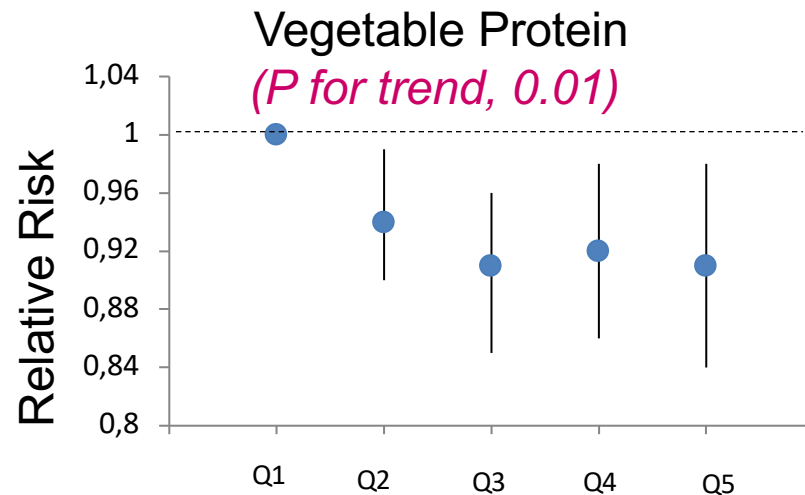
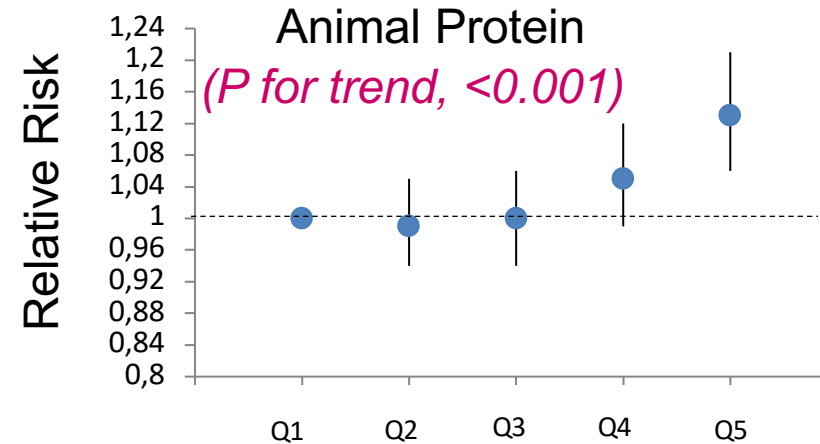
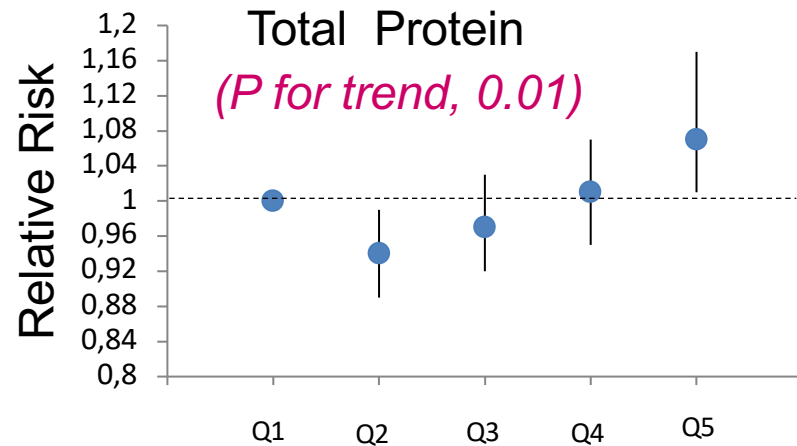
- “Incomplete” protein
- Lower concentration of protein

Sources:

- Legumes
- Nuts
- Seeds
- Whole grains
- Vegetables



Total protein and protein type and risk of type 2 diabetes: Pooled results from 3 cohorts



NHS: 1980-2010, N= 72,992

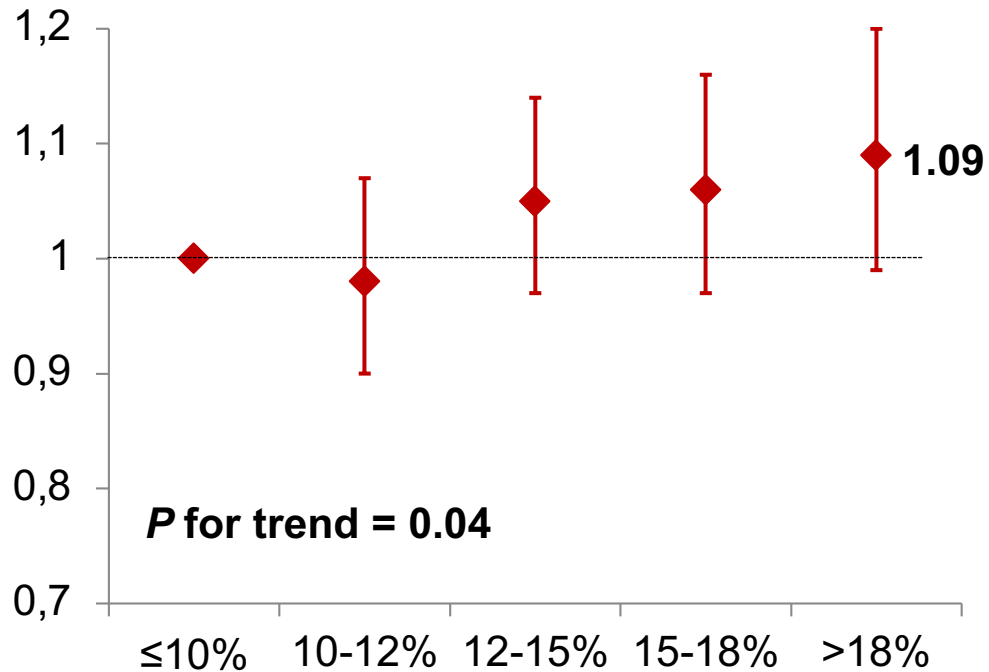
NHSII: 1991-2009, N= 92,088

HPFS: 1986-2010, N= 40,722

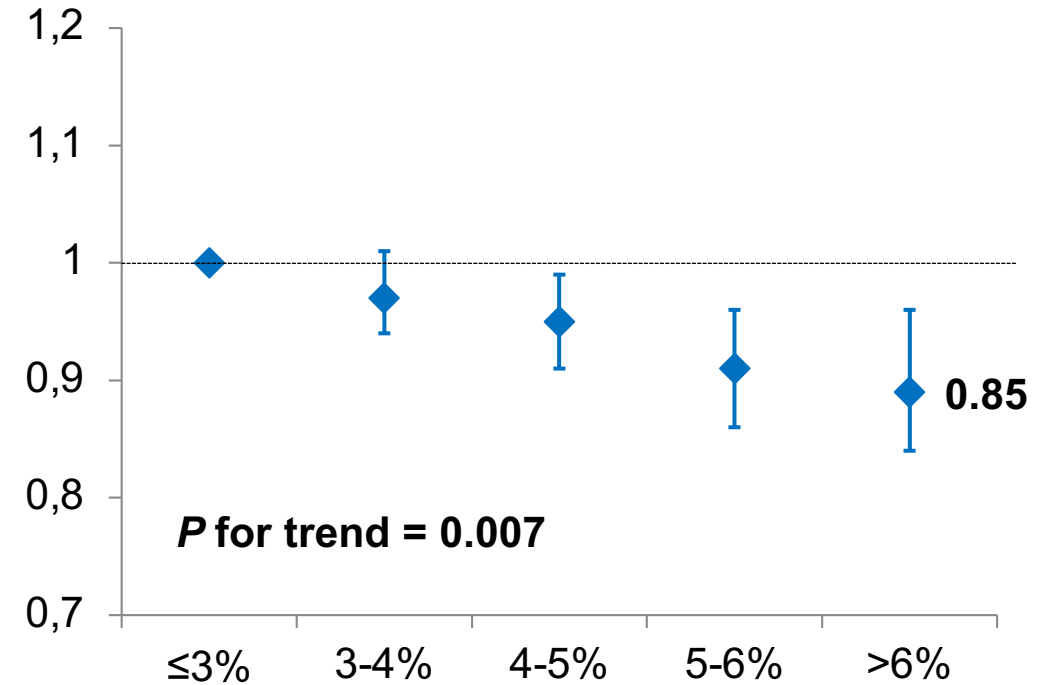
Adjusted for: age, family history of diabetes, smoking, alcohol, physical activity, race, total energy, post menopausal hormones, oral contraceptives, dietary fiber, glycemic index, dietary cholesterol, percent energy from trans fat saturated fat, MUFA, PUFA, and animal/vegetable protein + **BMI**

Type of Protein and *Cardiovascular Mortality*

Animal protein



Plant protein



Summary of Published Meta-Analyses on of RCTs on Plant Foods and Blood Lipids (Intervention Plant Foods Versus Comparison Diets)

Intervention Food/Food Group	Total Cholesterol, mmol/L	LDL Cholesterol, mmol/L	HDL Cholesterol, mmol/L	Triglycerides, mmol/L
Tree nuts	-0.09	-0.11	0.00	-0.02
Walnuts	-0.18	-0.14	0.002	-0.05
Almonds	-0.18	-0.15	-0.05	-0.04
Soy protein or products	-0.22	-0.23	0.07	-0.09
Dietary pulses	-0.14	-0.13	0.04	-0.06

2015 Dietary Guidelines Advisory Committee Report: Diet and Sustainability

- **Plant-based dietary pattern**

- Vegetables, fruits, whole grains, legumes, nuts, and seeds
- Less environmental impact than current average U.S. diet
- U.S. population should eat more plant-based foods and less meat while decreasing total calories
 - Don't need to go completely vegetarian
- Example dietary patterns
 - Dietary-guidelines based
 - Healthy Vegetarian
 - Healthy Mediterranean-style
 - Dietary Approaches to Stop Hypertension (DASH)



Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review (*Nelson et al. Adv Nutr 2016*)

- 23 studies reviewed:
 - Dietary patterns higher in plant-based foods, lower in animal-based foods, lower in total energy, are healthier and more sustainable
 - Meat identified as food with greatest impact on GHG emissions/land use
 - Sustainable diet that meets dietary requirements can be achieved without eliminating meat or dairy products and without increasing consumer cost

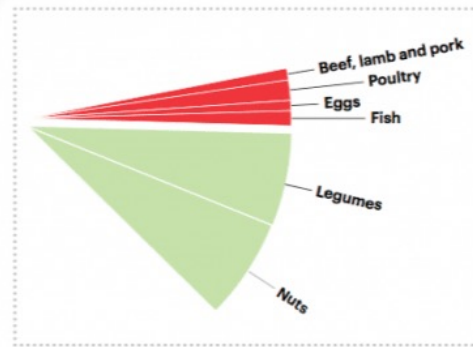


Planetary Health Diet

- Designed to improve human and planetary health
- Abundant vegetables, fruits, whole grains, legumes, nuts, and unsaturated oils
- Moderate seafood, poultry and dairy
- Limits red and processed meat, added sugar, refined grains, and highly processed foods
- Diet quality improvement could prevent 12 million deaths per year globally
- Feed 10 billion people a healthy diet within the planetary boundaries in 2050

Willett et al, EAT Lancet Commission Report 2019.

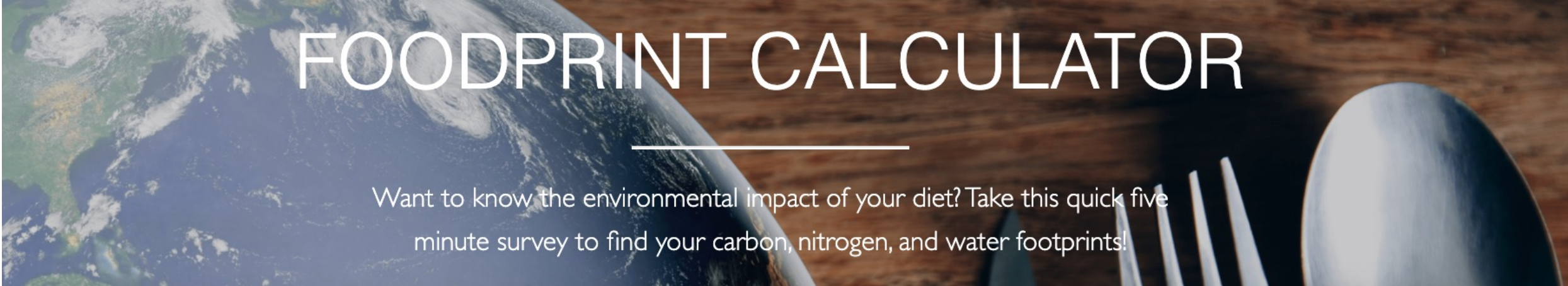




◆ Compared with current diets, this shift will require global consumption of foods such as red meat and sugar to decrease by 50%, while consumption of fruits, nuts, vegetables, and legumes must double.

◆ It is important to tailor these targets to local situations. For example, while North American countries currently consume almost 6.5 times the recommended amount of red meat, countries in South Asia eat only half the recommended amount.

Your Diet's Annual Environmental Impact



FOODPRINT CALCULATOR

Want to know the environmental impact of your diet? Take this quick five minute survey to find your carbon, nitrogen, and water footprints!

<https://harvard-foodprint-calculator.github.io/>

Strategies to reduce red meat and elevate your plate

- **Eat a little less red meat, any way you can**: Assess how often you eat red meat, and see if one of these strategies can help you find a way to cut back a bit.
- **Swap out red meat for healthier meats**: If you're thinking of a meal that features red meat, see if you can replace it with a better option, like poultry or seafood.
- **Consume less meat, enjoy more variety**: This approach boosts healthy plant-based foods like beans, nuts, whole grains, and other veggies, while still providing ways to incorporate some of your favorite animal-based foods.
- **Prioritize hearty and savory plant-based preparations**: Simple strategies for creating filling, delicious, and even budget-friendly plant-based dishes.

Can Plant-Based Meat Alternatives Be Part of a Healthy and Sustainable Diet?



Environmental impact of plant-based burgers

- An analysis commissioned by Beyond Meat found that the Beyond Burger generates 90% less greenhouse gas emissions, requires 46% less energy, 99% less water, and 93% less land use than a burger made from U.S. beef.

Nutrient composition of plant-based burgers is not optimal

- Although Beyond and Impossible burgers contain zero cholesterol, are lower in total and saturated fat than a beef burger patty (similar in protein and calories), they are both higher in sodium.

Highly processed nature of the plant-based burgers

- These products are generally using purified plant protein, with vitamins and other ingredients added to the patty. They are often consumed in fast-food settings.

Heme iron concern

- Impossible Foods adds heme from the roots of soy plants to the burger. One potential concern is that higher intake of heme iron has been associated with increased body iron stores and risk of diabetes.

A 8-week trial (n=36) found that Plant-based meat lowers cardiovascular risk factors compared with red meat

Outcome	Plant, mean $\pm$ SEM	Animal, mean $\pm$ SEM	Plant–Animal difference, mean (95% CI)	P value ²
Primary				
TMAO,³ μM	2.7 $\pm$ 0.3	4.7 $\pm$ 0.9	–2.0 (–3.6, –0.3)	0.012
Secondary				
IGF-1, ng/mL	147.6 $\pm$ 7.5	152.3 $\pm$ 8.3	–4.7 (–13.9, 4.5)	0.30
Weight, kg	78.7 $\pm$ 3.0	79.6 $\pm$ 3.0	–1.0 (–1.5, –0.5)	<0.001
Insulin, μ U/mL	9.2 $\pm$ 1.1	8.8 $\pm$ 0.9	0.4 (–0.7, 1.5)	0.38
Glucose, mg/dL	94.9 $\pm$ 1.6	94.5 $\pm$ 1.4	0.5 (–1.8, 2.8)	0.65
Lipids, mg/dL				
LDL-C	109.9 $\pm$ 4.5	120.7 $\pm$ 4.5	–10.8 (–17.3, –4.3)	0.002
HDL-C	62.5 $\pm$ 2.2	61.8 $\pm$ 2.5	0.7 (–2.4, 3.8)	0.66
Triglycerides	99.7 $\pm$ 7.3	100.2 $\pm$ 7.0	–0.6 (–10.5, 9.2)	0.89
Blood pressure, mm Hg				
Systolic	114.5 $\pm$ 2.1	113.1 $\pm$ 1.9	1.2 (–1.4, 4.1)	0.31
Diastolic	70.0 $\pm$ 1.4	68.8 $\pm$ 1.2	1.1 (–0.8, 3.2)	0.20

Conclusions

- Global meat production and consumption are increasing rapidly due to nutrition transition with enormous health and environmental implications.
- No single one-size-fits-all diet to improve human and planetary health: Vegetarian diet, Mediterranean diet, DASH, Flexitarian, etc.
- One can adapt core principles of a healthy diet to individual food preferences, health conditions, and cultural traditions
- Reduce food losses and waste
- Reorient agricultural priorities from producing high quantities of food to healthy food
- Technological innovations such as plant-based meat alternatives and cultured meat have the potential to reduce environmental impact of food system, although long-term impacts on human health are uncertain.