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Nutrient Availability in CGE Models

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Motivation

- Computable general equilibrium (CGE) models have proven useful for analysis of alternative environmental policies, especially accounting for economy-wide and welfare effects of policies relative to a baseline.
- The baseline is important as a point of departure, and tells a story of how trends in population, income, and technology might influence food demand and nutrition over time.
- Output from CGE models can be converted to nutritional indicators such as calories, protein, fats, and micro-nutrients.
- World food consumption varies across drivers of global change, especially across income scenarios.
- Some humility is needed for global economic modelers venturing into nutrition.
  - Nutrition is a complex subject
  - We can construct basic indicators and how they change over time in response to drivers of global change

Methods

- Economic Framework
  - Global computable general equilibrium
  - Simulation of world agriculture through 2050
  - 13 world regions
- If the CGE model consumer demand system can simulate calorie consumption over time by food group, other nutritional measures can be constructed.
  - protein, fat (grams per person per day) based on FAO food balance sheets
  - micronutrients based on food composition tables such as Harvard GENuS
- Application to global diet scenarios
  - Static diet (reference scenario)
  - 50 percent EAT-Lancet healthy diet
  - Income-driven diet

Future Agricultural Resources Model (FARM)

- Recursive dynamic CGE model: essentially a sequence of static equilibria with capital stocks updated between time steps, but lacking foresight of future economic variables
- Land use can shift among crops, pasture, and managed forests in response to population growth and changes in income, with behavioral responses determined by price and income elasticities
- FARM can substitute other inputs for land if land becomes expensive
- Crop yield is endogenous, even with underlying productivity trends that are exogenous to the model

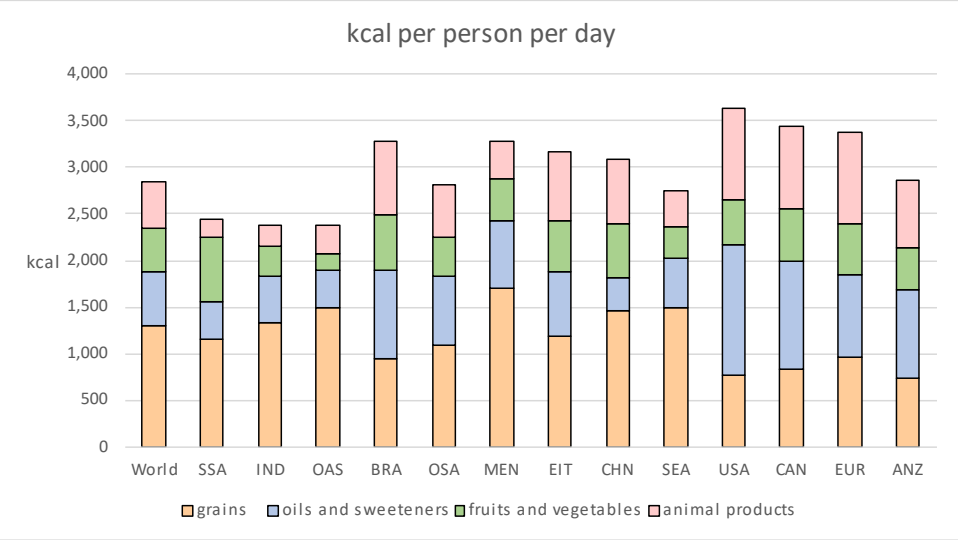
Key data sets

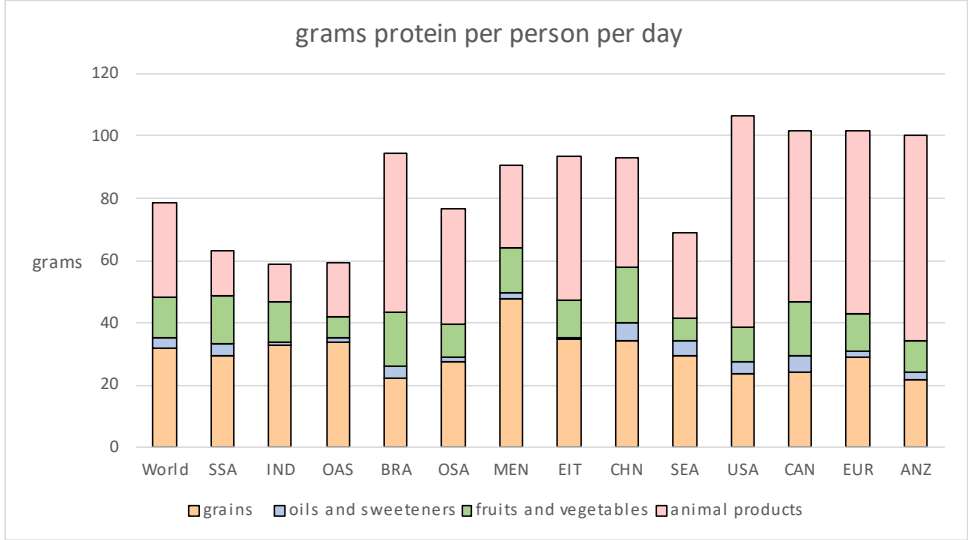
- Global social accounting matrix (SAM) from Global Trade Analysis Project (GTAP)
- Food balance sheets from the Food and Agriculture Organization (FAO) of the United Nations
- Tables for converting food consumption by weight to calories (food composition tables)

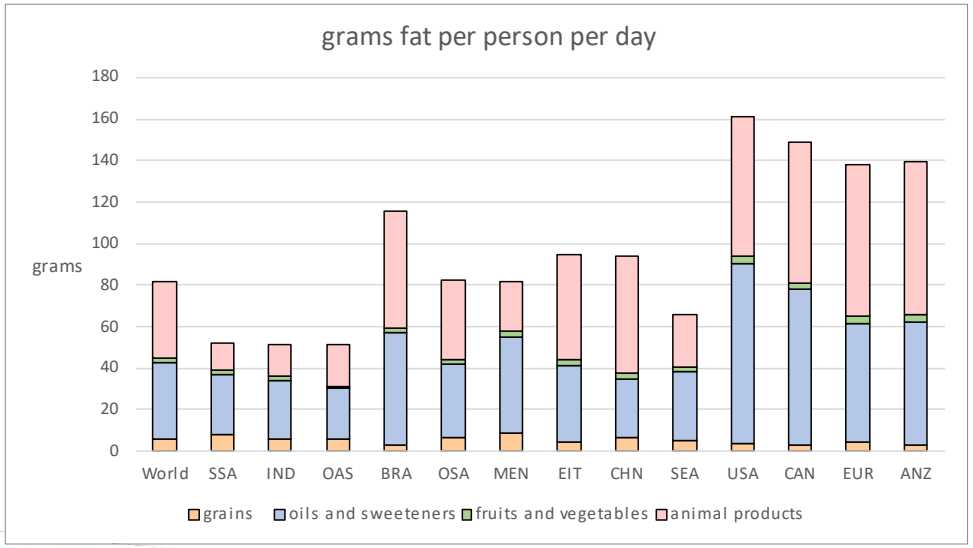
World regions in Future Agricultural Resources Model (FARM)

Symbol	Region name	Notes
SSA	Sub-Saharan Africa	
IND	India	
OAS	Other Asia (south)	
BRA	Brazil	
OSA	Other South America	Including Central America, Caribbean, and Mexico
MEN	Middle East and North Africa	Including Turkey
EIT	Economies in Transition	Russia, Belarus, Ukraine, Kazakhstan, Kyrgyzstan, Armenia, Azerbaijan, Georgia, Tajikistan, Turkmenistan, Uzbekistan
CHN	China	
SEA	Southeast and East Asia	Including Japan
USA	United States	
CAN	Canada	
EUR	Europe	Including Estonia, Latvia, Lithuania
ANZ	Australia and New Zealand	Including Oceania

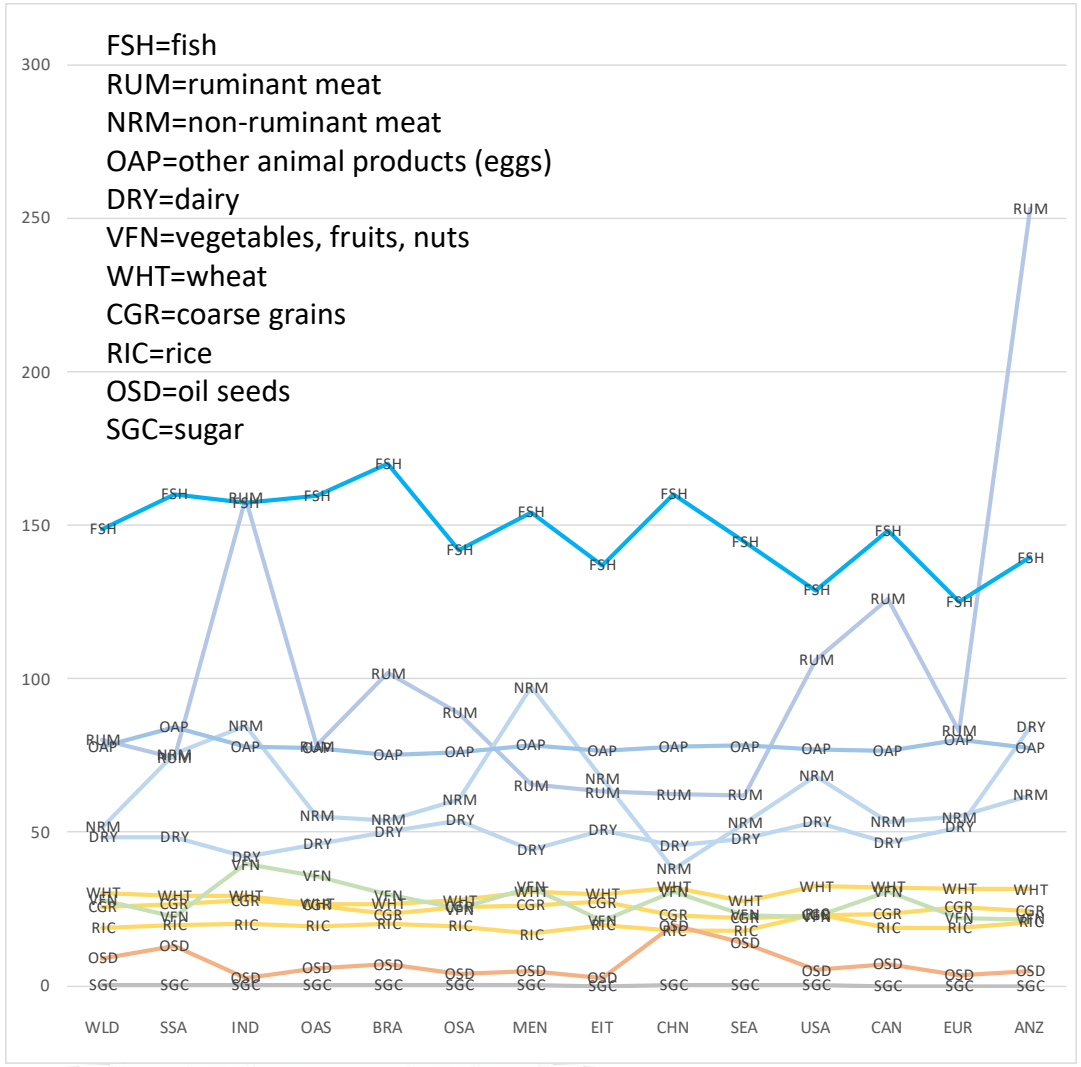
Historical macro-nutrient availability by world region (2011)



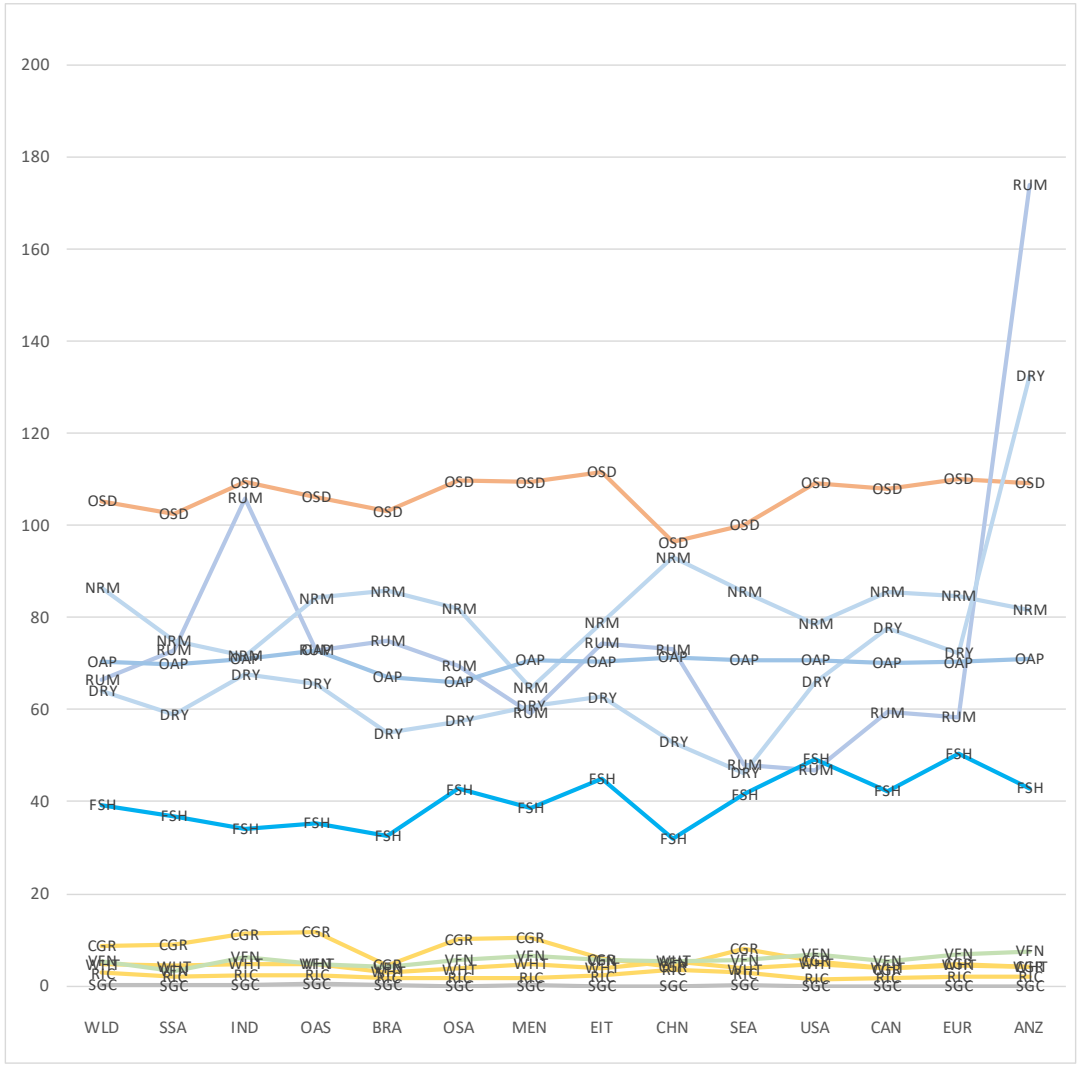




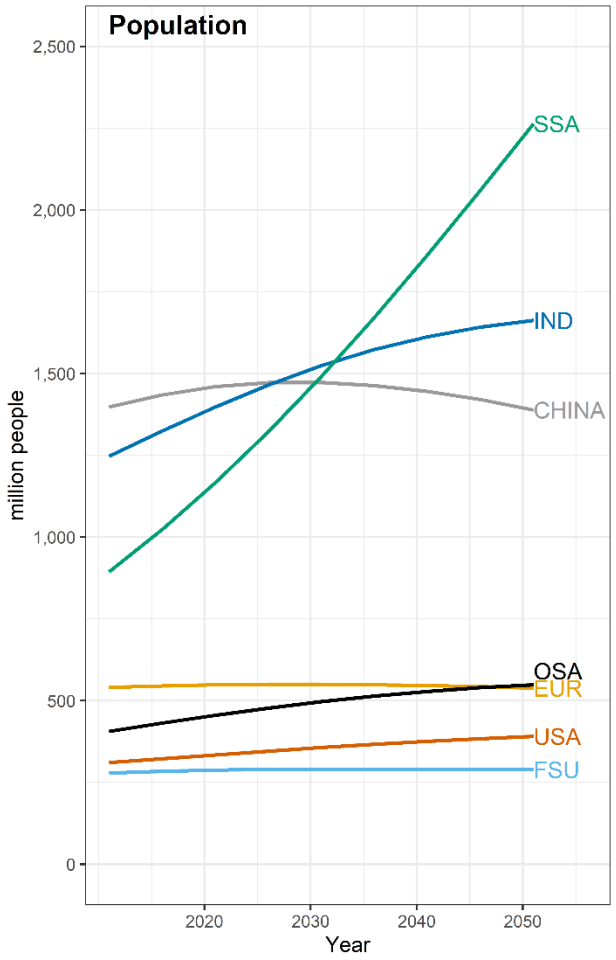
grams of protein per 1000 kcal

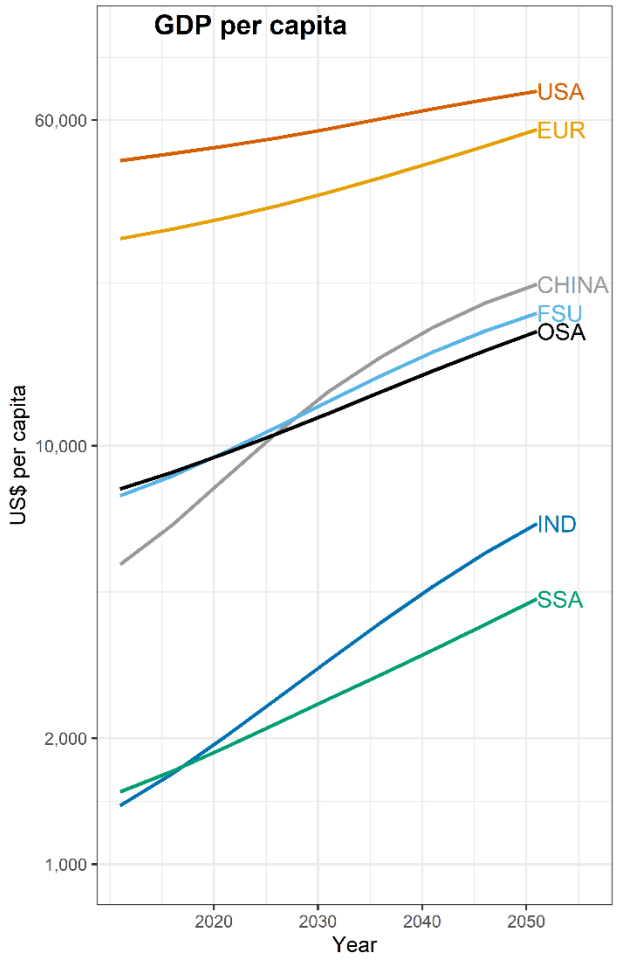


grams of fat per 1000 kcal

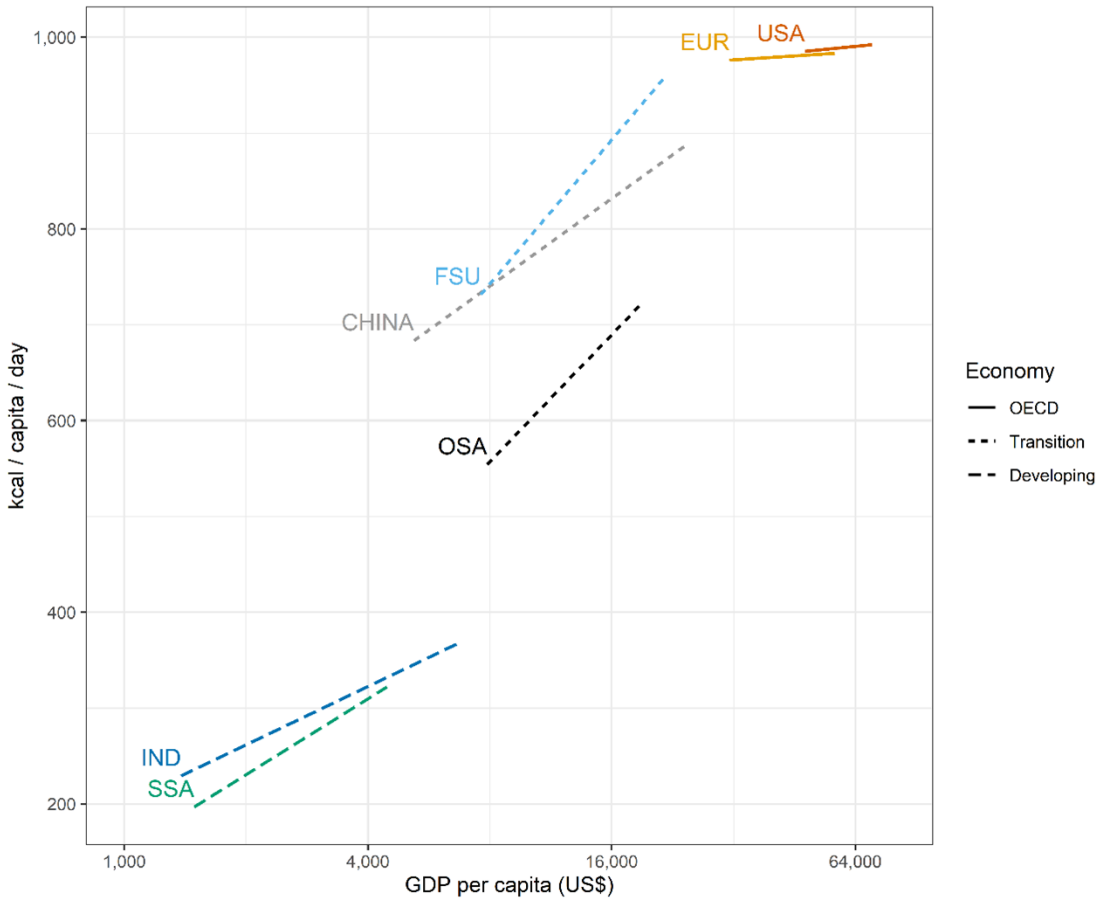


Projections of population and GDP per capita





Long-run income response of animal product consumption to income

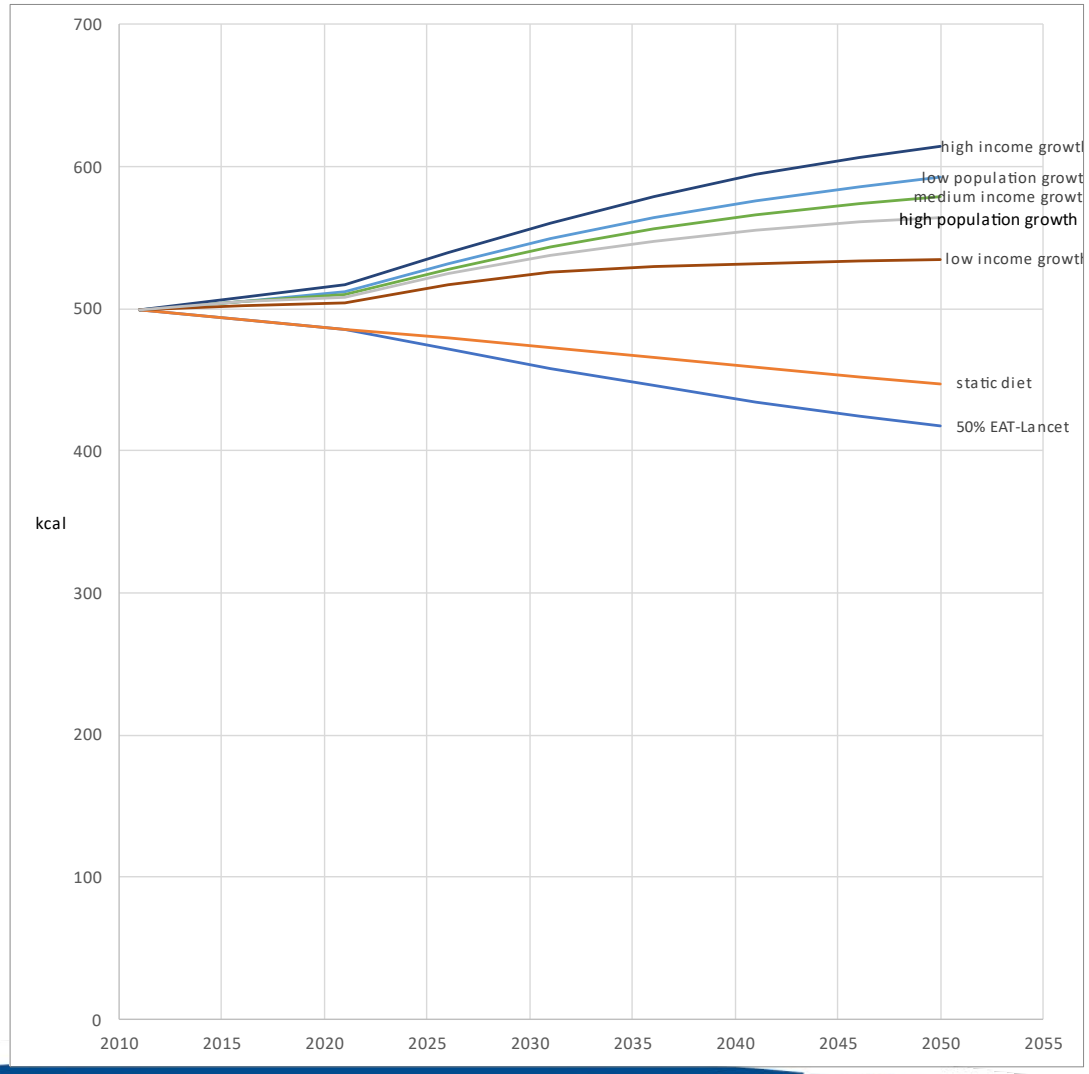


Scenarios

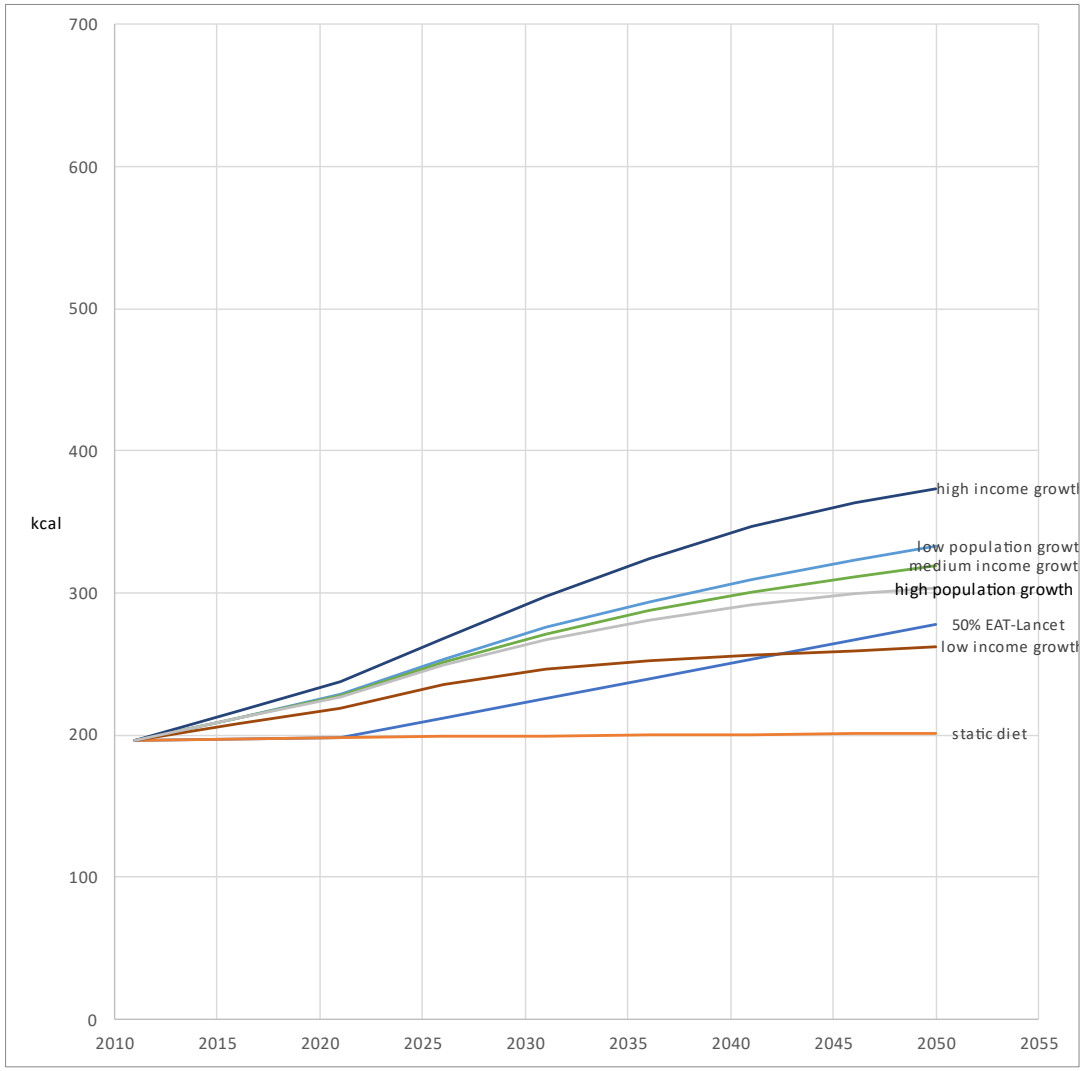
- (1) Static diet (reference scenario): All world regions maintain their 2011 historical diet. There is no income or price response in this scenario.
- (2) 50 percent EAT-Lancet Healthy Reference Diet: 50 percent convergence from 2011 historical diet toward the Healthy Reference Diet in Willet et al. (2019). With full convergence, average consumption of food calories becomes 2500 kcal/person/day within each world region, which is an increase for developing countries and a decrease for wealthy countries. Consumption of animal products increases in developing countries but declines in wealthy countries.
- Income-driven diets: based on historical food consumption patterns in response to increasing per capita income. The general pattern is for total per capita calories to increase, along with a greater share of animal products in the diet.
  - (3) Low income growth
  - (4) Medium income growth
  - (5) High income growth

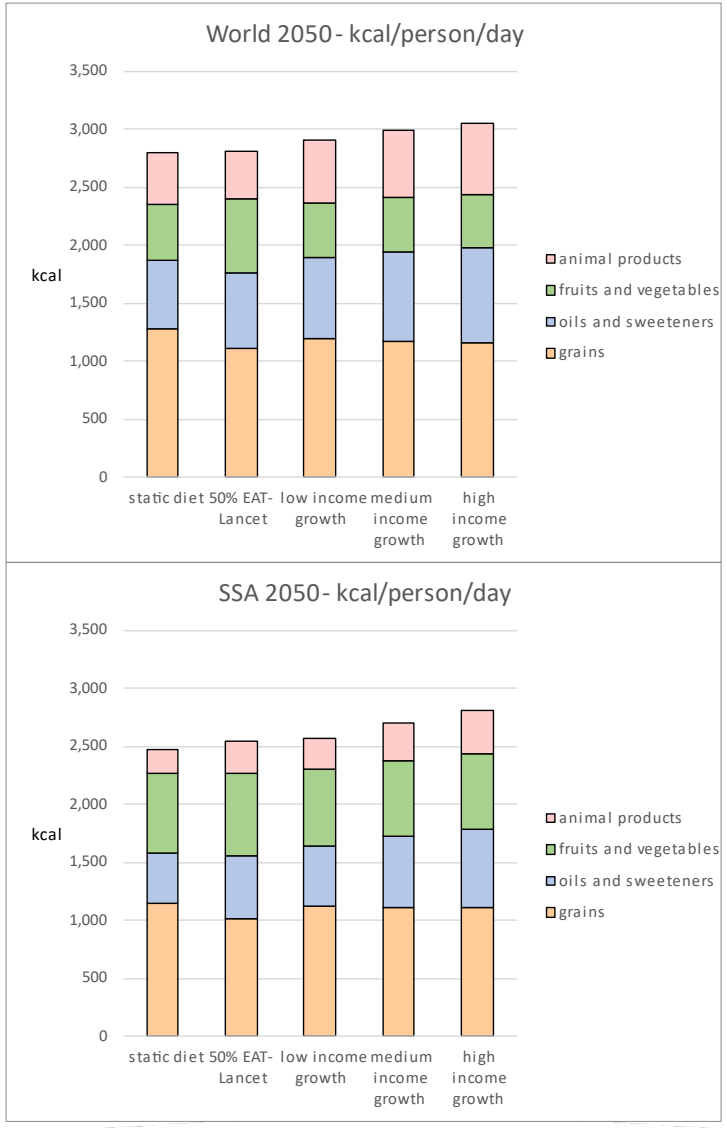
W. Willett et al. (2019) Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems, The Lancet 393: 447-492.

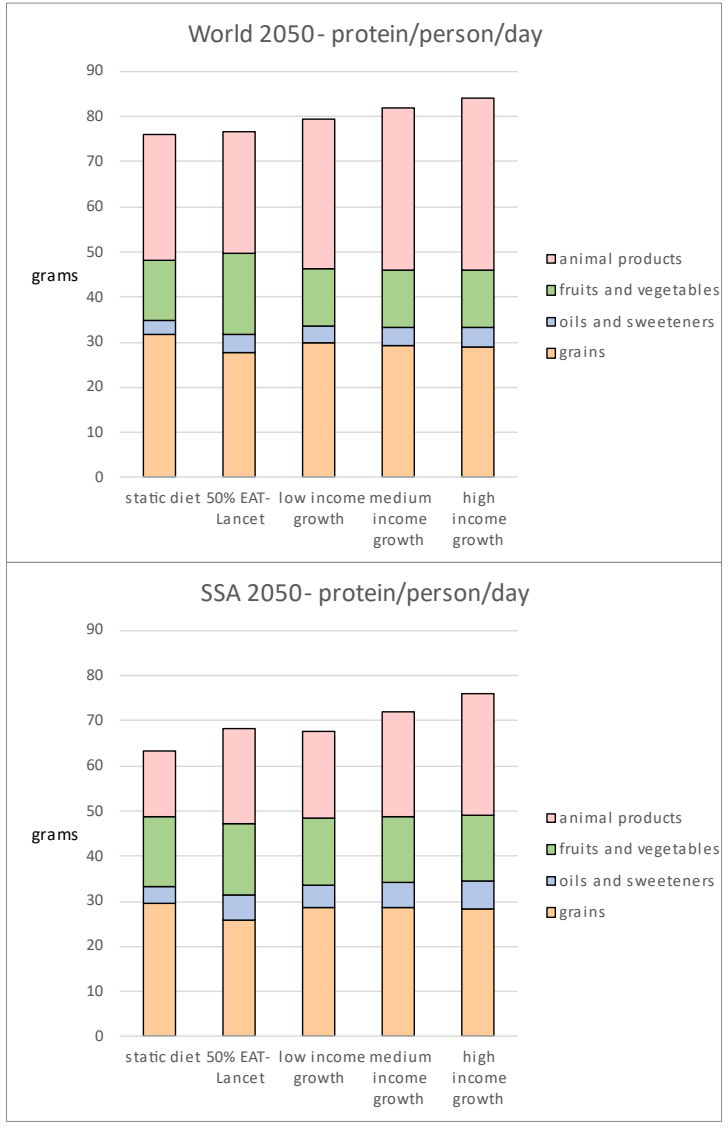
Per capita consumption of animal products (World)

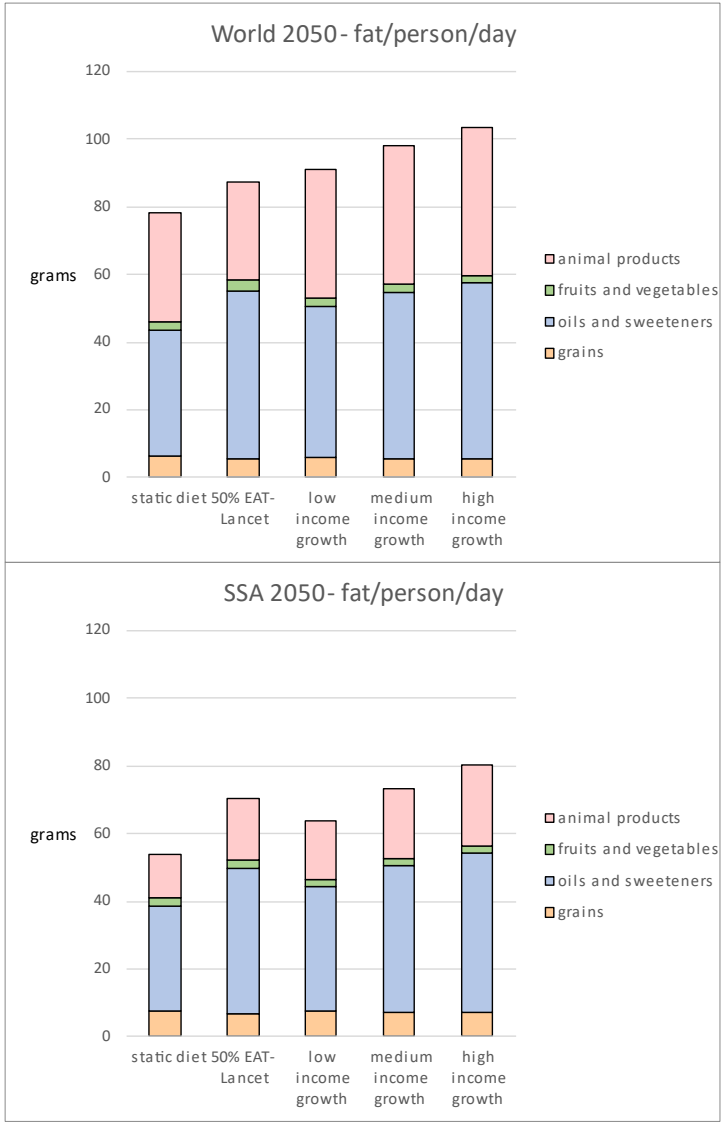


Per capita consumption of animal products (SSA)




World 2050- kcal/person/day
kcal
3,500
3,000
2,500
2,000
1,500
1,000
500
0
static diet
50% EAT-Lancet
low income growth
medium income growth
high income growth
animal products
fruits and vegetables
oils and sweeteners
grains


World 2050- protein/person/day
grams
90
80
70
60
50
40
30
20
10
0
static diet
50% EAT-Lancet
low income growth
medium income growth
high income growth
animal products
fruits and vegetables
oils and sweeteners
grains


World 2050- fat/person/day
grams
120
100
80
60
40
20
0
static diet
50% EAT-Lancet
low income growth
medium income growth
high income growth
animal products
fruits and vegetables
oils and sweeteners
grains

SSA 2050- kcal/person/day
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Future Directions

- Partition grams of fat using food composition tables
  - Saturated
  - Monounsaturated
  - Polyunsaturated
- Micronutrients by food group can also be tracked
- Number of food groups can be expanded
  - GTAP data cover five types of animal products (including fish)
  - Fruit and vegetable group could be partitioned
- If climate change affects nutrient density of crops and food products, this could be included in scenarios

Food Composition Table

	Nutrient	Unit (per 100 g food)
Macro-nutrients	Calories	kcal
	Protein	g
	Carbohydrates	g
	Fat	g
	Saturated fat	g
	Monounsaturated fat	g
	Polyunsaturated fat	g
	Dietary fiber	g
Micro-nutrients	Vitamin C	mg
	Vitamin A	micrograms RAE
	Folate	micrograms
	Calcium	mg
	Iron	mg
	Zinc	mg
	Potassium	mg
	Copper	mg
	Sodium	mg
	Phosphorus	mg
	Thiamin (B1)	mg
	Riboflavin (B2)	mg
	Niacin (B3)	mg
	B6	mg
	Magnesium	mg