Detailed Study Notes: Episode 446

How Climate Change Impacts Nutrient Status

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Introduction to this Episode

Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, such as through variations in the solar cycle. But since the 1800's, human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil and gas.

Climate change has the potential to negatively impact the nutrient value of plants, soil organisms, food stuffs, via a variety of ways. Climate change puts food supplies at risk. Floods, droughts, more intense hurricanes, heatwaves and wildfires can drive down crop yields, destroy livestock, and interfere with the transport of food. And rising carbon dioxide levels from human activity can make staple crops like rice and wheat less nutritious.

In this podcast the Sigma team takes a look at the evidence on how climate change will impact nutrient status, if left unchecked. There will also be a look at what solutions have been put forward to tackle this issue. This episode will focus more on how climate change impacts nutritional & nutrient status, as opposed to the converse (but equally important) issue of how food systems impact climate change.

Connection to Previous Episodes

In episode 320 of the podcast Dr. Hannah Ritchie was on the show discussing a range of topics including; the current state of the impact of climate change globally and what the evidence actually says about which food choices are better/worse from an environmental perspective.

For more on food systems or the impacts of food insecurity, check out episodes 339 and 344, with Prof. Corinna Hawkes and Prof. Martin Caraher, respectively.

In this episode the work of Prof. Barry Popkin was referenced, in relation to the 'nutrition transition' and the shifts in diets globally. In episode 380 of the podcast, Prof. Popkin was on to discuss his work in this area.

What Is Climate Change?

Climate change is a change in the usual weather found in a place.

- This could be a change in how much rain a place usually gets in a year. Or it could be a change in a place's usual temperature for a month or season.
- Climate change is also a change in Earth's climate. This could be a change in Earth's usual temperature. Or it could be a change in where rain and snow usually fall on Earth.
- Weather can change in just a few hours.
- Climate takes hundreds or even millions of years to change.

UN definition: 'Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, such as through variations in the solar cycle. But since the 1800s, human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil and gas.'

The Paris Agreement

- A 1.5 °C (2.7°F) target is the goal of the Paris Agreement, which calls for countries respond to reduce greenhouse gas emissions(GHGE), in order to limit global warming.
- **1.5 °C (2.7°F) is an indicator of the point at which climate impacts will become increasingly harmful for people and indeed the entire planet.**
- The Paris Agreement: the legally binding international treaty on climate change signed by 196 Parties at the 21st Conference of Parties (COP21) in 2015.

The average global temperature for the twelve months up to February 2022 was between 1.1 and 1.2°C above the 1850-1900 level.

For more research documents, you can consult this page from the EPA in Ireland.

Example of a Country's Action Plan: Ireland

In 2022 Ireland published this climate action plan. With the key targets being:

- Ireland target reduce emissions by 51% by 2030
- Even if we implement *all recommendations* made in last plan (2019), it will only reduce emissions by 28% by 2030, will meet EU obligations
- New government put in a new target of 55% reduction.
- New plans required on how to actually implement the plan so that we meet the targets.

Is Earth's Climate Changing?

1. Earth's temperature has gone up about 0.6 °C (1°F) in the last 100 years. This may not seem like much. But small changes in Earth's temperature can have big effects.
2. Some effects are already happening. Warming of Earth's climate has caused some snow and ice to melt. The warming also has caused oceans to rise. And it has changed the timing of when certain plants grow.

Nutrient Status

First it should be noted that we can look at an individual's/population's *"nutritional status"*. But we can also consider the *"nutrient status"* of a food, crop, soil, etc.:

- **Nutritional status** (of people) - In general it refers to the presence or absence of malnutrition. The term "malnutrition" applies to both underweight and overweight populations.
    - Malnutrition is defined as *"any disorder of nutrition status including disorders resulting from deficiency of nutrient intake, impaired nutrient metabolism, or overnutrition."*
- **Nutrient status** (of food/soil) - Nutrients in plants, soil organisms, food stuffs

How Climate Change Could Affect Nutrient Status

Consequences of climate change may include:

- intense droughts
- water scarcity
- severe fires
- rising sea levels
- Flooding
- melting polar ice
- catastrophic storms
- declining biodiversity

How can it impact nutrient status?

Climate change puts at risk the food supplies of people in both developing and developed countries, by both direct and indirect means:

1. **Indirectly (access and availability) -** Floods, droughts, more intense hurricanes, heatwaves and wildfires can drive down crop yields, destroy livestock, and interfere with the transport of food.
2. **Directly -** Rising carbon dioxide levels from human activity can make staple crops like rice and wheat less nutritious.

Why it matters:

- UN: *"Nearly one in three people in the world (2.37 billion) did not have access to adequate food in 2020 – that's an increase of almost 320 million people in just one year. Many more have deficiencies in essential nutrients."*
- 76% of the world's population gets most of its daily nutrients from plants—yet climate change is already causing droughts and flooding that can destroy staple food crops.
    - If extra CO2 in the atmosphere makes those crops less nutritious, it will be even harder to feed the world's growing population.
- In most of the places where food is grown today, crop yields are likely to be lower because of more frequent heat waves, worse air pollution, floods, and droughts. India was discussed as an example in the episode.
- Global warming compounded by climate-related natural disasters impairs the ability to grow enough nutritional quality food.

Report: The state of food security and nutrition in the world 2021

- Joint publication by FAO, IFAD, UNICEF, WFP & WHO
- It includes new estimates of the cost and affordability of healthy diets, which provide an important link between the food security and nutrition indicators and the analysis of their trends.
- There is now a *"vast, evidence-based body of knowledge of the major drivers behind the recent changes in food security and nutrition."*
- These drivers (which are increasing in frequency and intensity) include:
    - Conflicts
    - Climate variability and extremes
    - Economic slowdowns and downturns
- All of these drivers are exacerbated by the underlying causes of poverty and very high and persistent levels of inequality.
- Millions of people around the world suffer from food insecurity and different forms of malnutrition because they cannot afford the cost of healthy diets.

Change in Nutritional Quality of Grains & Legumes

Medek et al., 2017 - Estimated Effects of Future Atmospheric CO2 Concentrations on Protein Intake and the Risk of Protein Deficiency by Country and Region

- If CO2 levels continue to rise as projected, the populations of 18 countries may lose more than 5% of their dietary protein by 2050 due to a decline in the nutritional value of rice, wheat, and other staple crops.
- Estimated that roughly an additional 150 million people may be placed at risk of protein deficiency because of elevated levels of CO2 in the atmosphere.
- First study to quantify this risk.

Myers et al., 2015 - Effect of increased concentrations of atmospheric carbon dioxide on the global threat of zinc deficiency

    - Increasing concentrations of atmospheric carbon dioxide (CO2) lower the content of zinc and other nutrients in important food crops.
    - Modelling dietary intake of bioavailable zinc for the populations of 188 countries under both an ambient CO2 + elevated CO2 scenario
- Methods
    - Per capita per day bioavailable intake of zinc for the population's concentrations (375–384 ppm) using food balance sheet data for 2003–07 from the FAO.
    - Plus data for air CO2 enrichment and open-top chamber experiments to model zinc intake at elevated CO2 concentrations
    - Used these data on zinc bioavailability and population-weighted estimated average zinc requirements to estimate the risk of inadequate zinc intake among the populations of the different nations under both scenarios (ambient and elevated CO2).
- Results
    - The total number of people estimated to be placed at new risk of zinc deficiency by 2050 was 138 million (95% CI 120–156).
    - Most affected - Africa and South Asia, with nearly 48 million residing in India.
    - Global maps of risk show significant heterogeneity.

Climate change and nutrition associated disease

1. Jessica Fanzo – Nature reviews
2. Nutrition from a climate change perspective

Crop Yield Potential – Future Food Production

The Lancet Countdown:

"In 2019, every 1 °C temperature increase was associated with a 1.64% global increase in the probability of severe food insecurity drives malnutrition (both undernutrition and overweight/obesity) and diet-related NCDs."

Springmann et al., 2016 - Global and regional health effects of future food production under climate change: a modelling study

- Modelling study, to estimate excess mortality attributable to agriculturally mediated changes in dietary and weight-related risk factors by cause of death for 155 world regions in the year 2050.
- Comparative risk assessment of changes in fruit and vegetable consumption, red meat consumption, and bodyweight for deaths from coronary heart disease, stroke, cancer, and an aggregate of other causes.
- Calculated the change in the number of deaths attributable to climate-related changes in weight and diets for the combination of four emissions pathways (a high emissions pathway, two medium emissions pathways, and a low emissions pathway) and three socioeconomic pathways (sustainable development, middle of the road, and more fragmented development), which each included six scenarios with variable climatic inputs.
- Results:
    - Climate change will lead to per-person reductions of 3·2% (SD 0·4%) in global food availability, 4·0% (0·7%) in fruit and vegetable consumption, and 0·7% (0·1%) in red meat consumption.

- These changes will be associated with 529 000 climate-related deaths worldwide (95% CI 314 000–736 000), representing a 28% (95% CI 26–33) reduction in the number of deaths that would be avoided because of changes in dietary and weight-related risk factors between 2010 and 2050.
- Twice as many climate-related deaths were associated with reductions in fruit and vegetable consumption than with climate-related increases in the prevalence of underweight, and most climate-related deaths were projected to occur in south and east Asia.
- Adoption of climate-stabilisation pathways would reduce the number of climate-related deaths by 29–71%, depending on their stringency.

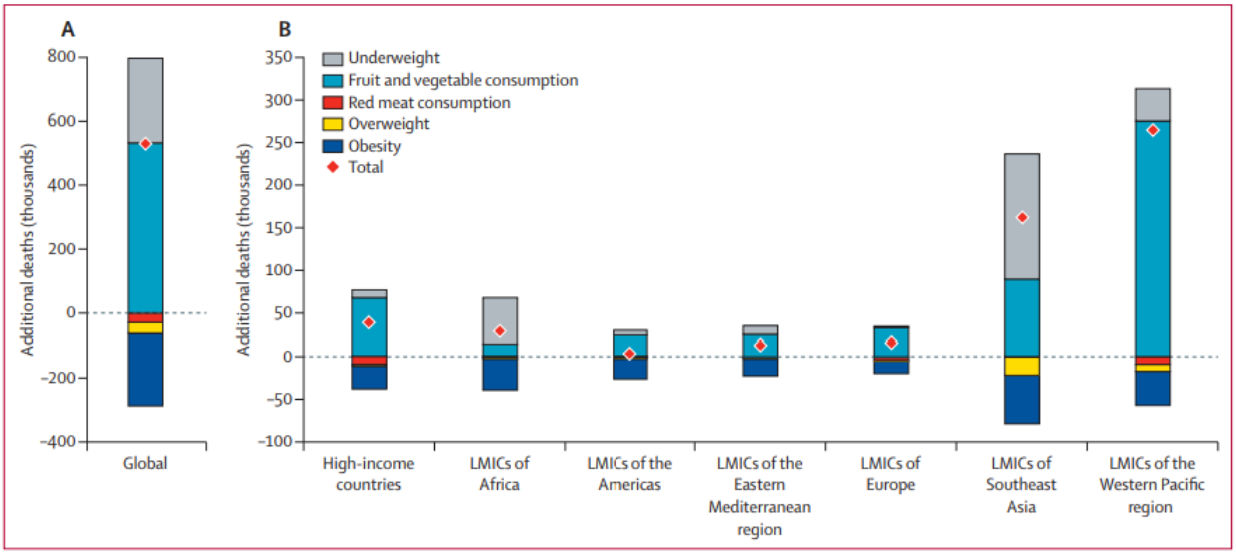

Figure 2: **Climate-related deaths (in thousands) in 2050 by risk factor**
(A) Climate-related deaths worldwide and (B) by region. The risk factors include changes in fruit and vegetable consumption, red meat consumption, and the prevalence of underweight, overweight, and obesity. The regional aggregates include all regions (global), high-income countries, and LMICs of Africa, the Americas, the Eastern Mediterranean region, Europe, Southeast Asia, and the Western Pacific Region. LMICs=low-income and middle-income countries. Confidence intervals are listed in appendix pp 67–70.

Image from: Springmann et al., 2016 - DOI: https://doi.org/10.1016/S0140-6736(15)01156-3

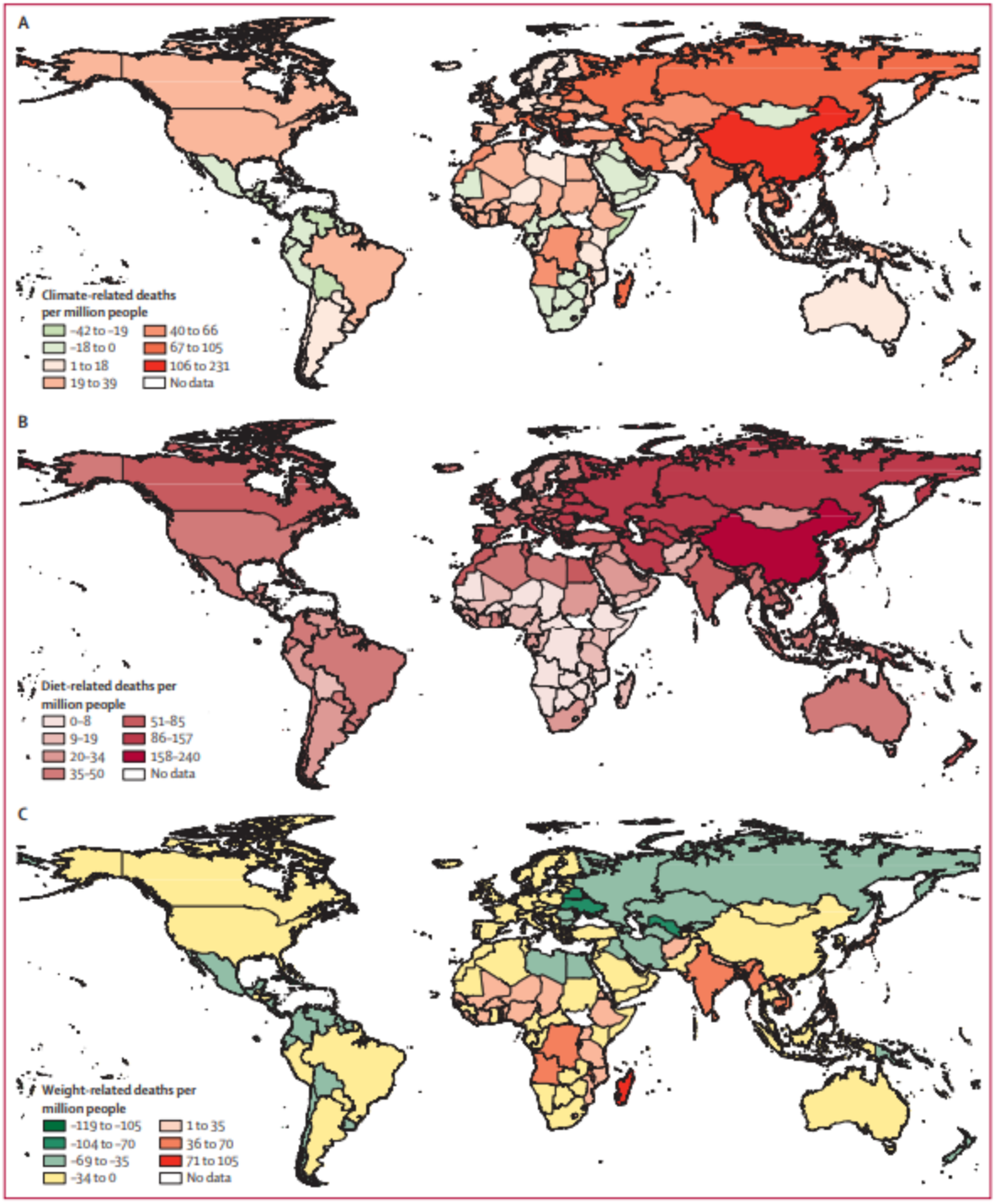

***Figure 3*: Climate-related deaths per million people in 2050**
Climate-related deaths per million people in 2050 for (A) changes in all dietary and weight-related risk factors, (B) changes in consumption-related risk factors, and (C) changes in weight-related risk factors. Confidence intervals are listed in appendix pp 64–66.

Image from: Springmann et al., 2016 - DOI: https://doi.org/10.1016/S0140-6736(15)01156-3

Financial insecurity and poverty

- Reduced crop yield potential increased poverty leading to malnutrition
- While the quantity and quality of food will decrease, the price of staple crops will increase, reducing affordability of a safe and nutritious diet, particularly for low-income populations.
- Changing environmental conditions facilitate the transmission of many water-borne, air-borne, food-borne and vector-borne pathogens, with potential knock-on effects on the burden of malnutrition.

Increase in non-communicable diseases lower fruit and veg intake related to climate change

Based on the previously mentioned Springmann et al. (2016) paper in the Lancet:

- Growing population, increasing incomes linked to dietary changes and are associated with high GHGE.
- The regions of the world producing the least GHGE tend to be those that are most vulnerable to the negative effects of climate change.
- Limiting the global rise in GHGE is essential for food and nutrition security in low-income countries, but it is high-income countries that are responsible for producing the most GHGE.
- In addition, emerging middle-income countries are transitioning towards unhealthy and high GHGE diets - increasing wealth intakes of animal-based products, fat, sugar and processed foods increase and fibre decreases.
- Alongside this transition is the increase in the prevalence of non-communicable diseases.

Popkin, 2006: Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases
[note: see episode 380 for a conversation with Prof. Popkin]

Reduction of beef consumption, alternative protein sources and plant-based diets

- Development of plant proteins in the EU
- The pros and cons of alternative proteins

Edible Insects: Pros & Cons (credit: Future Learn)

1. Nutrition

Pros	Cons
Good sources of protein and fat	Nutritional value varies depending on the species, developmental stage and type of feed
Meet essential amino acids requirements	Contain chitin which reduces protein digestibility
Rich in polyunsaturated fatty acids, vitamins and minerals, such as zinc, iron and B vitamins	Still unknown how processing and cooking techniques affect their nutritional value

2. Safety

Pros	Cons
Safe for consumption when reared in a controlled environment	Possibility of allergy in people allergic to crustaceans
Wild insects can be made safe for consumption after processing	Wild insects may be contaminated with pesticides, toxins or pathogens

3. Sustainability

Pros	Cons
Require less feed than livestock and can grow on biowaste	Still unclear of environmental impact of large-scale production
Rearing can potentially reduce greenhouse gas emissions	Research still needs to identify efficient species and biowaste sources to use in rearing
Can be used in animal feed reducing the need for crop production	Production is still expensive due to high manual labour

Lab grown meat

- Sustainability benefits and elimination of animal slaughter. It is predicted to become one of the largest alternative protein markets globally.
- The primary benefit is that the nutritional profile of lab-grown meat can be tailored and personalised. This means that products could be designed to be low in saturated fat and targeted at those with high cholesterol, for example. Lab-grown meat is also created under sterile lab conditions, reducing the risk of foodborne illness almost entirely.
- However, lab-grown meat is still in the early stages of development FAO – Codex Agenda. Regulation is still under consideration by organisations and authorities across the world and we are yet to see approved products in Europe.

Hayak & Garrett, 2018 - Nationwide shift to grass-fed beef requires larger cattle population

- Model a nationwide transition from grain- to grass-finishing systems using demographics of present-day beef cattle.
- To produce the same quantity of beef as the present-day system, a nationwide shift to exclusively grass-fed beef would require increasing the national cattle herd from 77 to 100 million cattle, an increase of 30%.
- The demand for beef could not be met from a purely grass-fed system, as yields would be too low.

Regardless of the production system, the only way to reduce the environmental impact was to reduce beef consumption. Inevitably this means people will need to change their diets and eat less meat.

Single food items shouldn't be the main target

Studies that have looked at dietary patterns with the greatest environmental impact, such as GHGE, land use and water use, have concluded that typically diets with more animal products have higher GHGE than plant-based diets.

Hallstrom *et al.*, 2021 - Dietary climate impact: Contribution of foods and dietary patterns by gender and age in a Swedish population

Methods:

- Dietary information was derived from a self-administered 132-item food-frequency questionnaire (FFQ) (available at www.simpler4health.se)
- Participants in the Swedish Mammography Cohort (25, 540 women) and the Cohort of Swedish Men (26, 578 men) aged 56–95 years.
- These two population-based cohorts were representative of the Swedish population in the age group of 56–95 years in terms of similar age distribution, attained education and prevalence of overweight.

Results:

- Animal-based foods, delivering on average 42% of total energy, accounted for 71% of the total mean dietary climate impact in the population, corresponding to 1.4 tons of CO2e/person/year.
- Within those, the biggest are red meat (29%) and dairy (30%), with the remainder being seafood, poultry and eggs at total 12%.
- Plant-based foods, delivering on average 41% of total energy, accounted for 18% of the total dietary climate impact in the population, corresponding to 0.35 tons of CO2e/person/year.
- Junk food, providing on average 17% of total energy but little or no nutritional value, accounted for 12% of total dietary climate impact in the population, corresponding to 0.24 tons of CO2e/person/year

1. Older individuals and women had the lowest dietary climate impact.
2. Dairy and red meat had the largest climate impact in women and men, respectively.
3. Animal-based foods dominated dietary climate impact and had highest impact per kg.
4. Food loss and waste was responsible for 18% of dietary climate impact.

Policy & Guidelines

Paris Agreement – 2015 - As discussed earlier.

United Nations Framework Convention on Climate Change

- Aim: to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty'
- This means limiting global warming, 'holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1·5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change'
- specifically refers to the threat climate change poses to food production and the need to safeguard food security against adverse impacts of climate

UN 2015: Sustainable Development Goals (SDG)

- Two of the SDG are specifically about nutrition security and sustainable diets:
    - to reduce hunger (SDG 2)
    - increase good health through nutrition security (SDG 3)
- Other SDGS include: climate action, life on land, life below water, no poverty and responsible consumption and production, will affect food and nutrition security.
- Much of the work to date has been identifying the variation in GHGE associated with the production of different food commodities (e.g. animal v. plant products).
    - In general, GHGE are highest in the production of ruminant animals (e.g., cows, sheep, goats) their digestive system produces methane, followed by other animals (e.g. poultry, pigs) and lower in the production of plant-based foods.
    - Rice has one of the higher GHGE of plant-based foods because methane is emitted in production from flooded rice fields.
- Livestock production carries the greatest environmental burden and nutritionally it is disproportionately higher than for the amount of nutrients derived from other food commodities.
- The demand livestock production places on land use and water use is typically higher than for most other food commodities, although water demand can be higher for fruit and vegetables depending on where they are grown.

Hannah Ritchie et al., 2018 - The impact of global dietary guidelines on climate change

- Quantify the greenhouse gas (GHG) intensity of global and national level recommended 'healthy' diets (WHO and national recommendations)
- Methods:
    - National food-based dietary guidelines were reviewed based on those publicly available in FAO repositories. These cover 86 countries across all regions, with countries at all stages of development.
    - The average diets of six national guidelines—India, China, Germany, Canada, Australia and the USA, in addition to the WHO healthy (WHO, 2015) and income-dependent 2050 diet (Tilman and Clark, 2014)—were quantified in terms of annual GHG emissions per capita based on commodity-specific life-cycle analysis (LCA) meta-analyses.
- Large variability in GHG intensity, from 687 kg CO2 e capita per year for guideline Indian diet to 1,579 kg in USA.
- USA and Australian recommended 'healthy' diet, once corrected for waste, exceed emissions of income-dependent diet in 2050

EAT–Lancet Commission on healthy diets from sustainable food systems

- EAT–Lancet Commission proposed a Planetary Health Diet, rich in plant-based foods, that can improve health while reducing environmental degradation
- Planetary Health Diet recommendations have been associated with a 34% greater reduction in premature mortality (through effects on diet-related NCDs), over three times higher reduction in GHGe, and better attainment of global health and environmental goals than following current national dietary guidelines – Springmann study.
- Shifts towards the Planetary Health Diet will look different across regions given the existing inequities in the intake of the different foods.

EAT: *"flexible by providing guidelines to ranges of different food groups that together constitute an optimal diet for human health and environmental sustainability. It emphasizes a plant-forward diet where whole grains, fruits, vegetables, nuts and legumes comprise a greater proportion of foods consumed. Meat and dairy constitute important parts of the diet but in significantly smaller proportions than whole grains, fruits, vegetables, nuts and legumes. the dietary targets also suggest that the average adult requires 2500 kcal per day. While this*

amount will vary based on age, gender, activity levels and health profiles, overconsumption is a waste of food with both health and environmental costs."

Practical Application

1. Reduction of red meat, encourage more flexible dietary approaches as opposed to strict vegan, etc.
2. Prioritizing lower impact foods (plant based) within meat, dairy and seafood categories, limited consumption of sweets/snack/sugary drinks
3. Decreased over-consumption of total calories
4. Improvements in production including reduction of food loss and waste
5. Protein alternatives (but are they good for health? Questions remain)