Environmental Challenges to sustainable food systems

Daniel Mason-D'Croz
Cornell Food Systems & Global Change

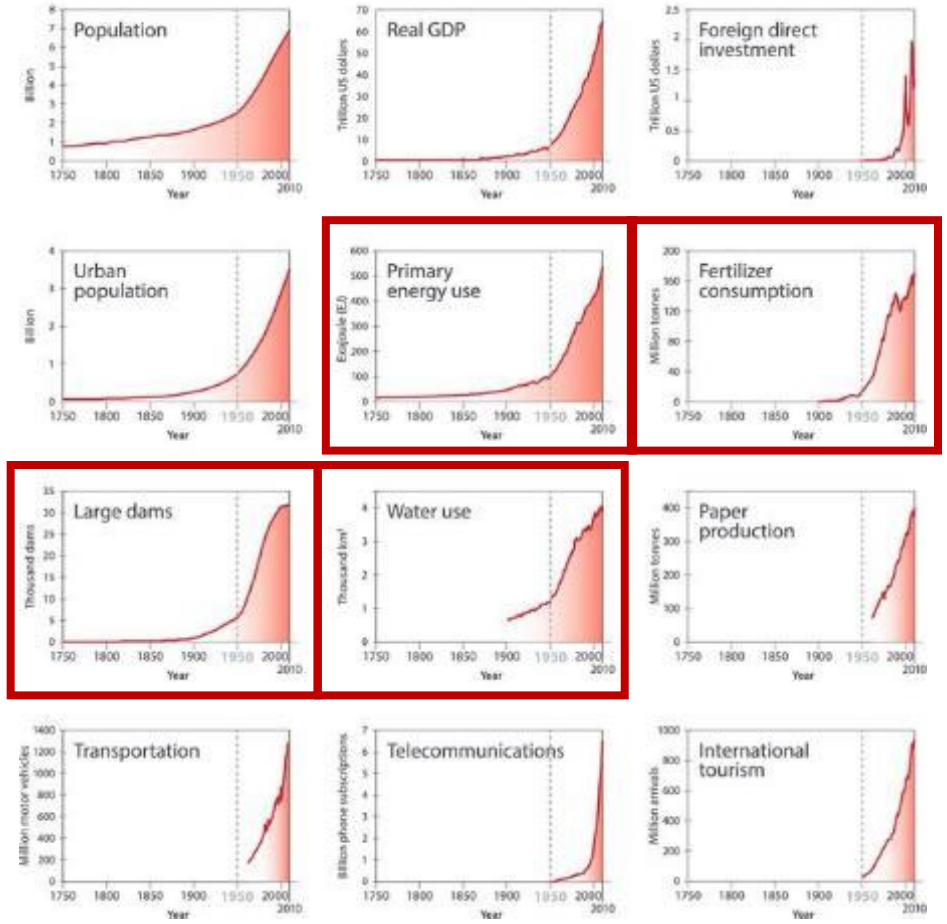
National Academies Food and Nutrition Board Workshop on Maximizing Agriculture to Enhance Nutrient Composition to Better Fulfill Dietary Recommendations
January 30, 2024

Cornell CALS
College of Agriculture and Life Sciences
Global Development

Cornell Atkinson Center for Sustainability

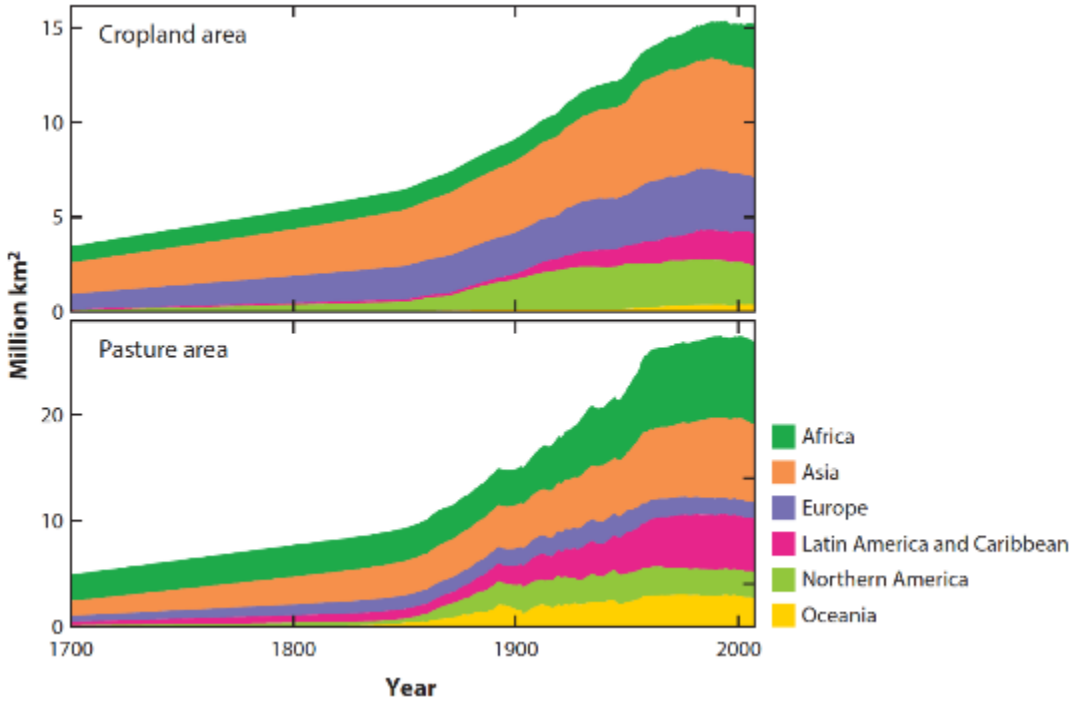
Food Systems in the Anthropocene

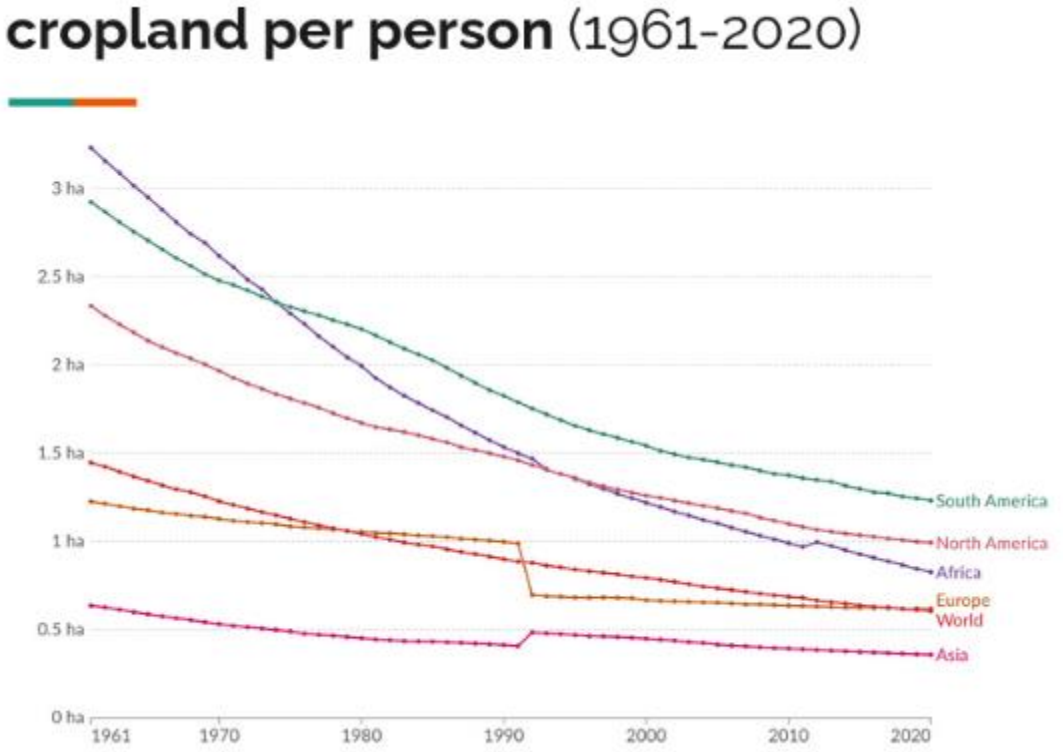
- **Intensification since the 20th century allowed production to meet growing demand, but it has led to increased use of natural resources**
- **Agri-food systems:**
  - Contribute between 20-37% of GHG emissions (Rosenzweig et al. 2020)
  - Account for 70% of water use (Heinke et al. 2020)
  - Primary user of arable land
  - Major driver of biodiversity decline



Steffan et al. (2015) *Anthropocene Review*

Land-use and Biodiversity

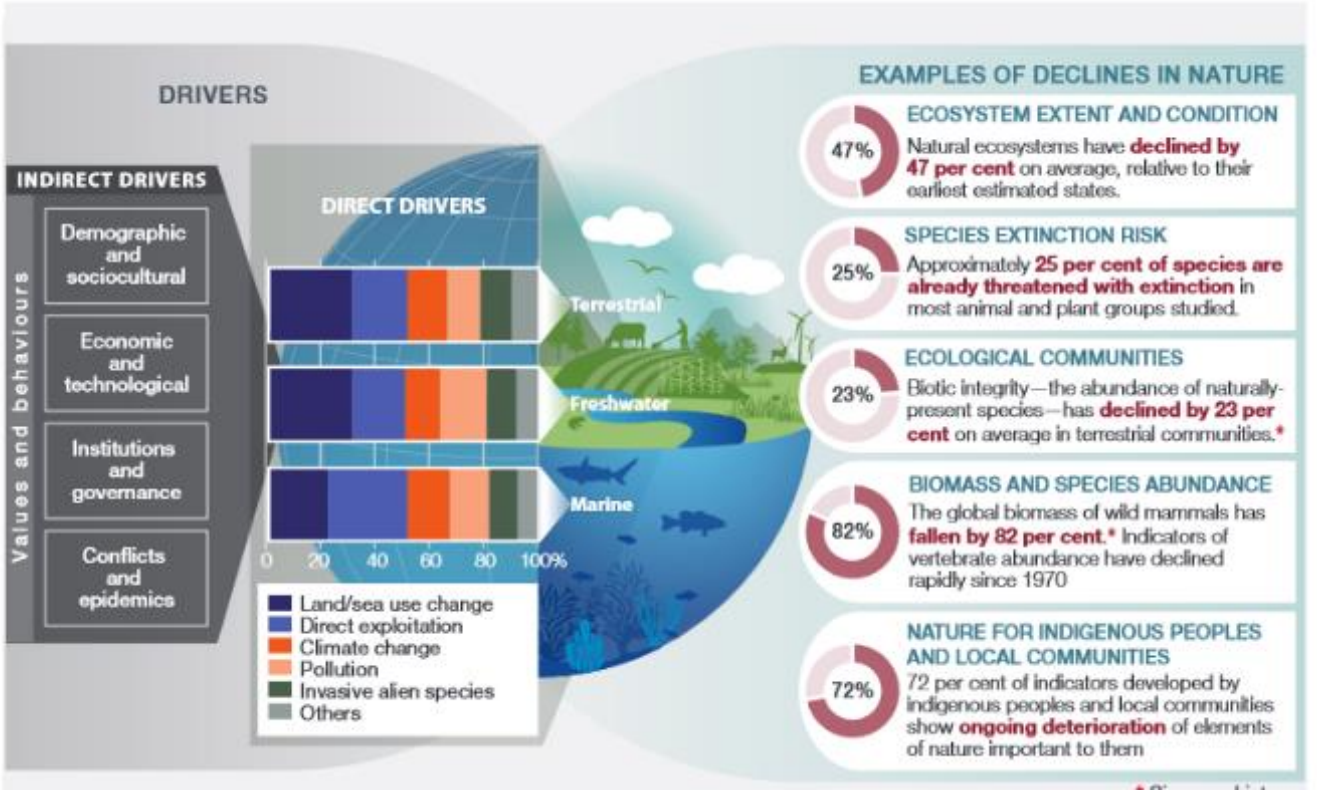




Ramankutty et al. 2018, Annual Review of Plant Biology; FAO 2022 FAOSTAT

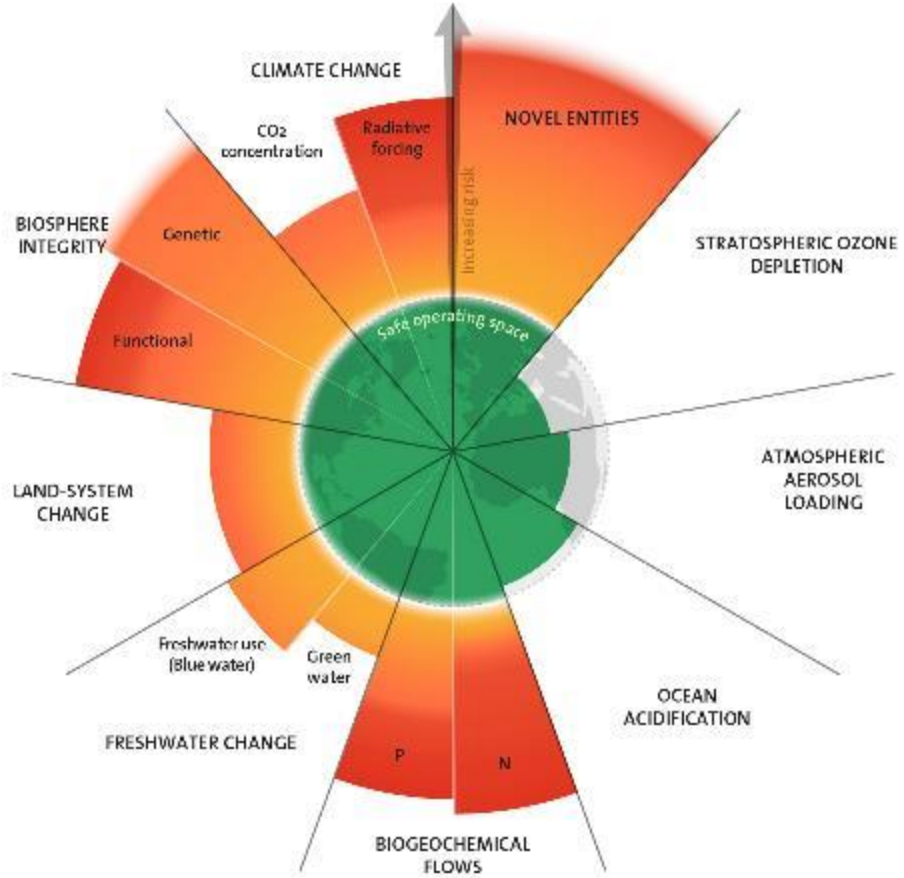
Land-use and Biodiversity

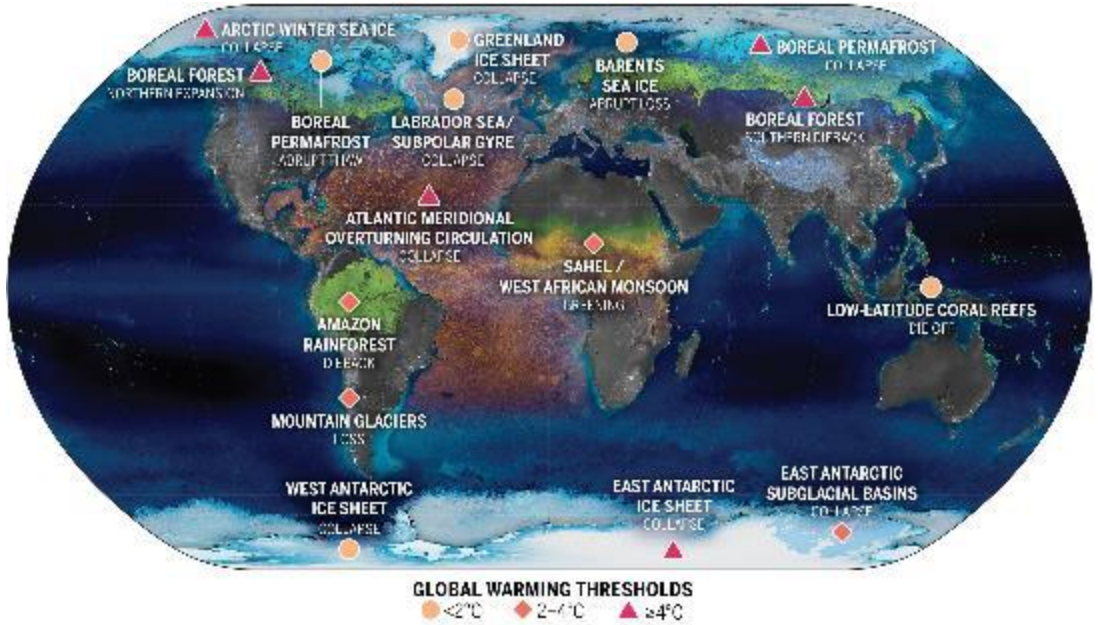
- **Biodiversity**
  - Agriculture major driver of biodiversity loss
  - Nature provides substantial value to human wellbeing
- **Agricultural Diversity**
  - Global Food production is increasingly homogenous.
  - Relatively small number of commodities supply most of the world's food (Khoury et al 2014)
  - Agrobiodiversity is associated with improved food security (Waha et al 2022)



IPBES 2019

Moving out of a safe operating space?

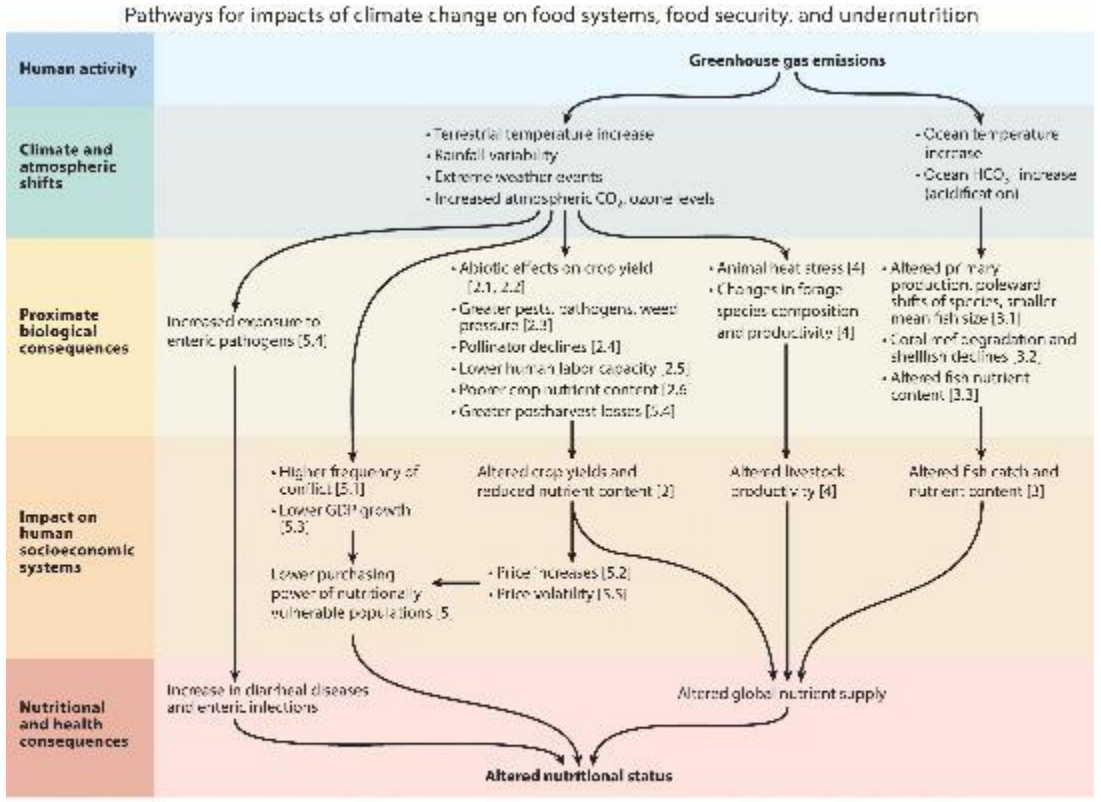




Richardson et al. 2023 Science Advances; McKay et al. 2022 Science

Climate change a multiple vector threat

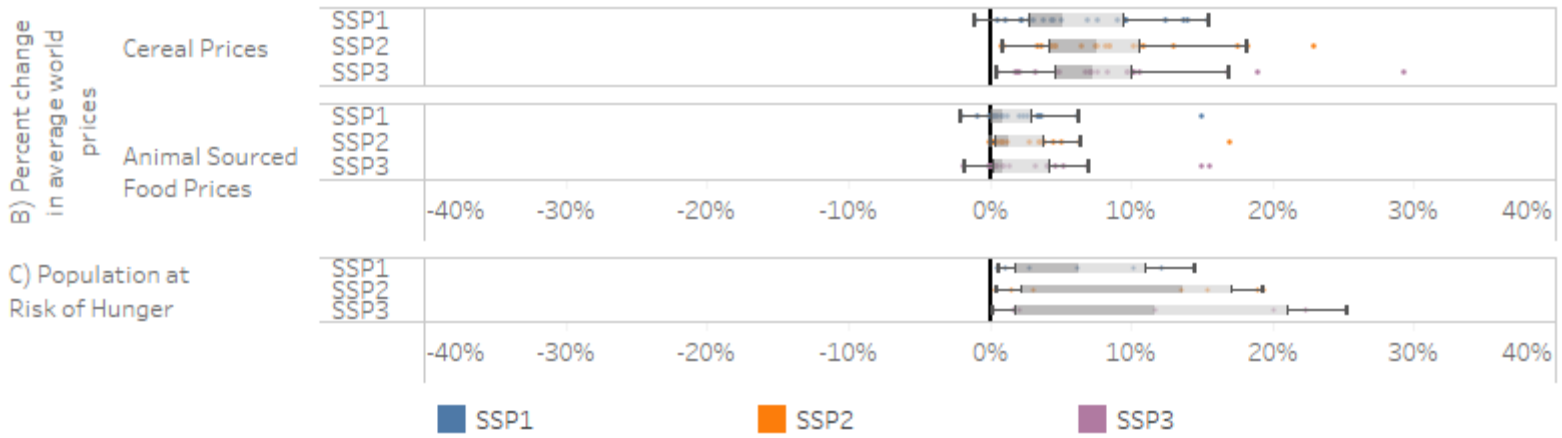
- **It's more than crop yields**
- **Negative impacts**
  - Livestock productivity
  - Crop quality
  - Labor productivity
  - Shifting patterns of pests and diseases
  - Increased food loss and waste
  - Faster depreciation of capital and infrastructure
  - Threaten key transport corridors (e.g., Panama Canal, St Lawrence Seaway, and the Rhine, Amazon, and Mississippi Rivers)

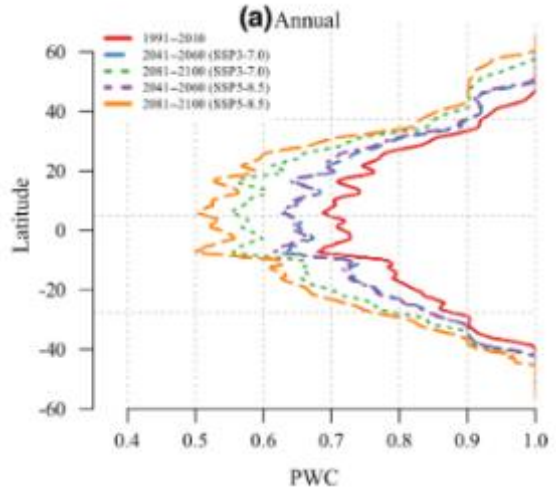


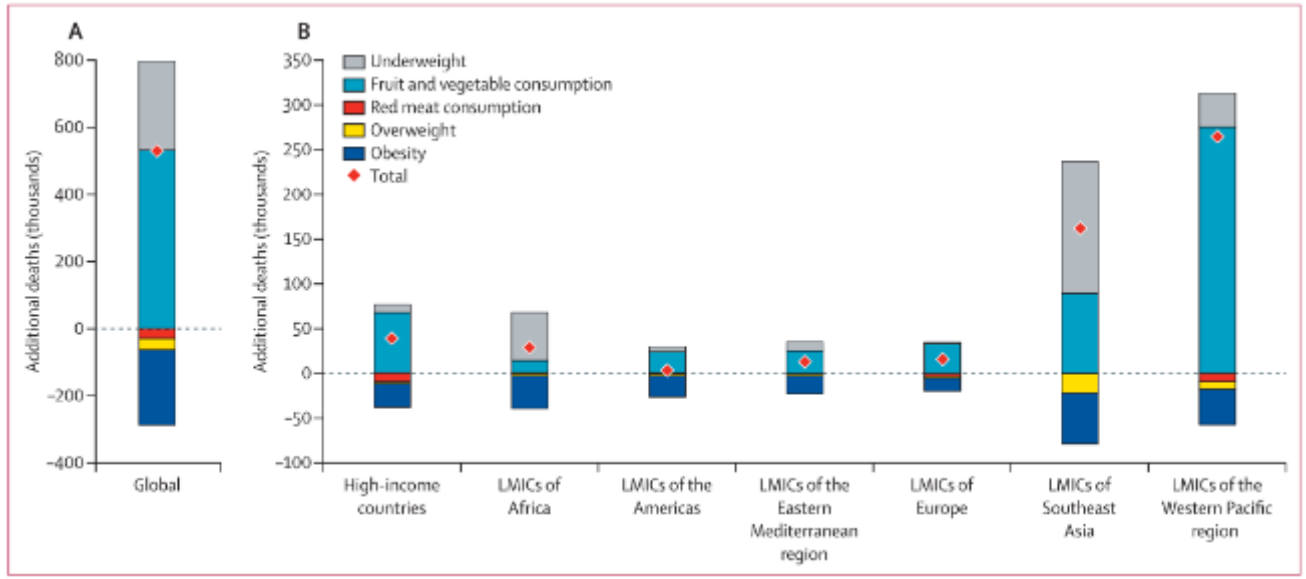
Myers SS, et al. 2017.
Annu. Rev. Public Health. 38:259–77

Climate change likely will lead to:

- higher food prices
- lower food availability
- increased hunger
- poorer quality diets
- Worsening conditions for agricultural workers



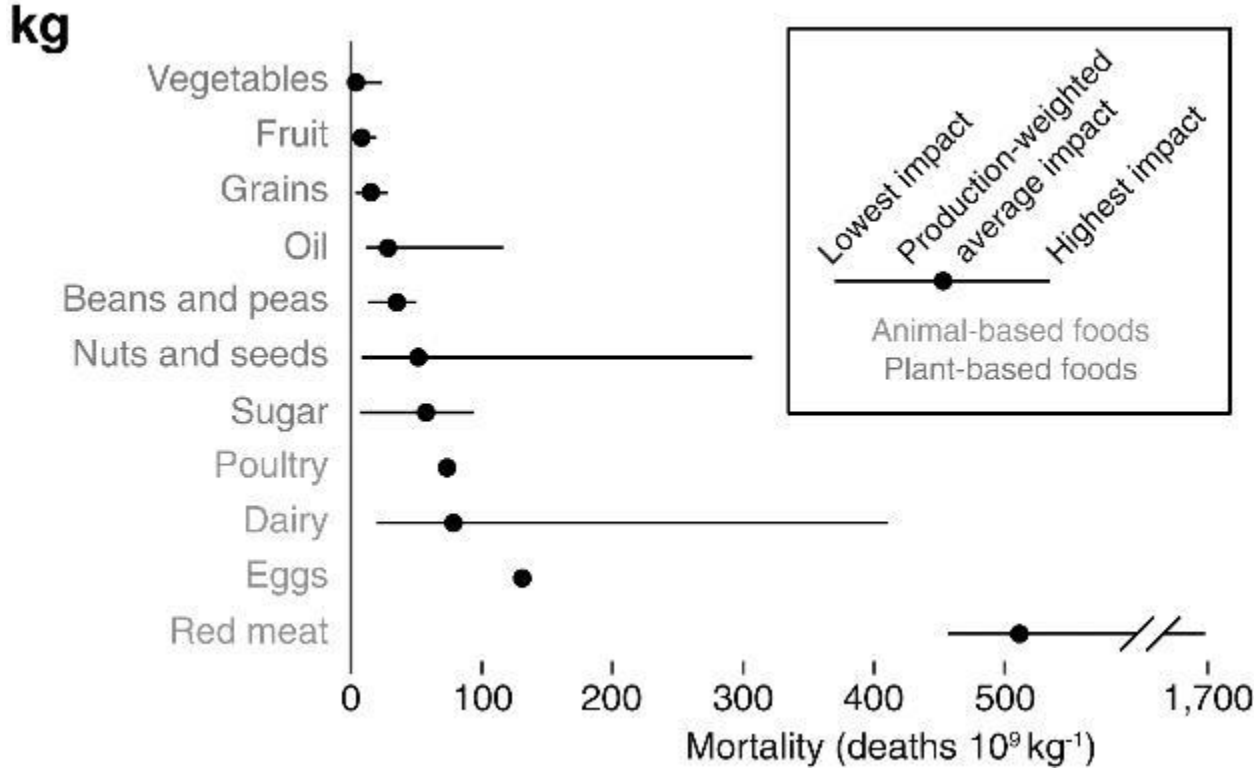




Mbow et al. 2019, IPCC SRLCC; Springmann et al. 2016, *The Lancet*; Nelson et al. 2023 *Global Change Biology*

Not just global challenges

- **Food production is a major source of air, water, soil pollution, which is felt locally**
- **Agriculture globally is the primary source of PM2.5 air pollution (Bauer et al 2016)**



Domingo et al 2021 PNAS

A few final thoughts

- **Agriculture is contributing to and impacted by environmental challenges**
- **There is substantial scope to reduce environmental impacts based on current best practices, and innovations on the horizon**
- **Multiple environmental, economic, and health objectives means there will be trade-offs**
  - Productivity growth is critical, but increasing efficiency alone if not coupled with aggregate reduction in natural resource use may not be enough to avoid crossing critical environmental thresholds (e.g, 1.5/2C)
  - Intensifying agriculture can have negative environmental impacts, need more innovation to reduce these
  - Current food demand trends for more resource and carbon intensive food will make satisfying food demand and achieving environmental goals more difficult
  - Dietary change has potential to improve health outcomes, and reduce environmental pressures but not clear how it would be achieved

References

- Bauer et al (2016) Significant atmospheric aerosol pollution caused by world food cultivation. Geophysical Research Letters, 43(10). DOI: 10.1002/2016GL068354
- Domingo et al. (2021) Air quality–related health damages of food. PNAS, 118(20. DOI: http://doi.org/10.1073/pnas.2013637118
- FAO (2022). FAOSTAT. https://www.fao.org/faostat/en/
- Heinke et al. (2020). Water Use in Global Livestock Production—Opportunities and Constraints for Increasing Water Productivity. Water Resources Research, 56(12). DOI: http://doi.org/10.1029/2019WR026995
- Khoury et al. (2014). Increasing homogeneity in global food supplies and the implications for food security. PNAS, 111(11). DOI: /10.1073/pnas.1313490111
- Mbow et al. (2019). Food Security. In N. Benkeblia, A. Challinor, A. Khan, & J. Porter (Eds.), *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*. IPCC. https://www.ipcc.ch/srccl-report-download-page/
- McKay et al. (2022) Exceeding 1.5°C global warming could trigger multiple climate tipping points. Science, 377(6611). DOI: 10.1126/science.abn7950
- Myers et al. (2017) Climate change and global food systems: Potential impacts on food security and undernutrition. Annual Review of Public Health, 38. DOI: 10.1146/annurev-publhealth-031816-044356
- Nelson et al. (2024) Global reductions in manual agricultural work capacity due to climate change. *Global Change Biology*. DOI: 10.1111/gcb.17142
- Ramankutty et al. (2018). Trends in Global Agricultural Land Use: Implications for Environmental Health and Food Security. Annual Review of Plant Biology, 69(1). DOI: 10.1146/annurev-arplant-042817-040256
- Richardson et al. (2023) Earth beyond six of nine planetary boundaries. *Science Advances*, 9(37). DOI: 10.1126/sciadv.adh2458
- Rosenzweig et al. (2020) Climate change responses benefit from a global food system approach. Nature Food, 1(2). DOI: 10.1038/s43016-020-0031-z
- Springmann et al. 2016. Global and regional health effects of future food production under climate change: a modelling study. *The Lancet*, *387*(10031), 1937–1946. DOI: 10.1016/S0140-6736(15)01156-3
- Steffen et al. (2015). The trajectory of the Anthropocene: the great acceleration. *The Anthropocene Review*, *2*(1), 81-98. DOI: 10.1177/2053019614564785
- Waha et al. (2022) The benefits and trade-offs of agricultural diversity for food security in low- and middle-income countries: A review of existing knowledge and evidence. Global Food Security, 33. DOI: 10.1016/j.gfs.2022.100645