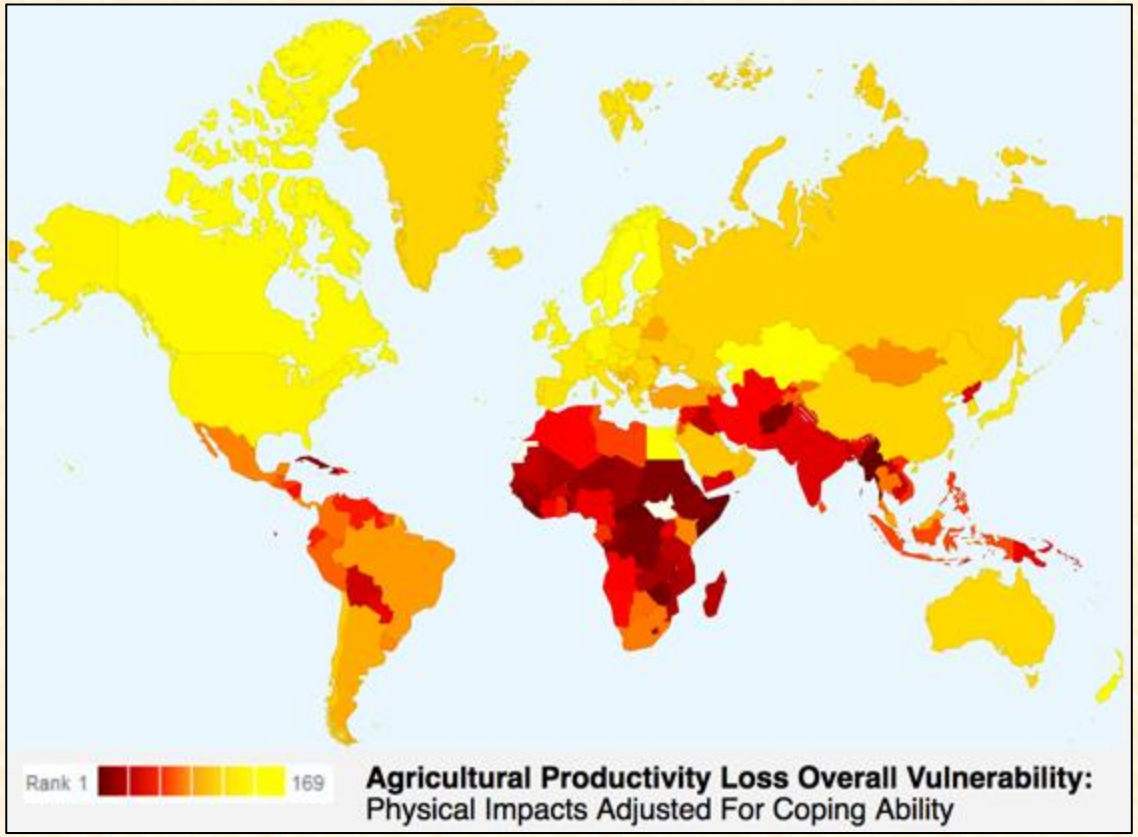
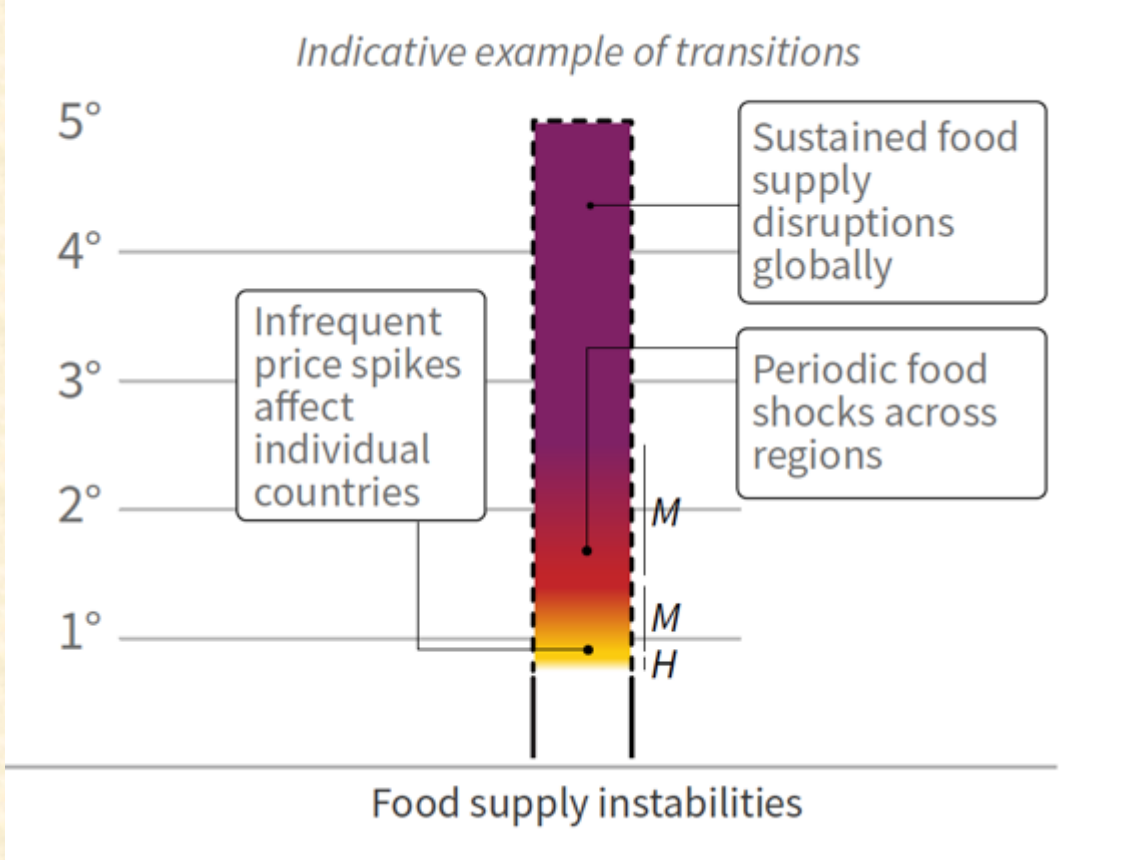
Agriculture and Climate Change

Eric Toensmeier

Climate Change Impacts on Agriculture

Overall Impact of CC on Agriculture





https://www.cgdev.org/page/mapping-impacts-climate-change

IPCC *Climate and Land*

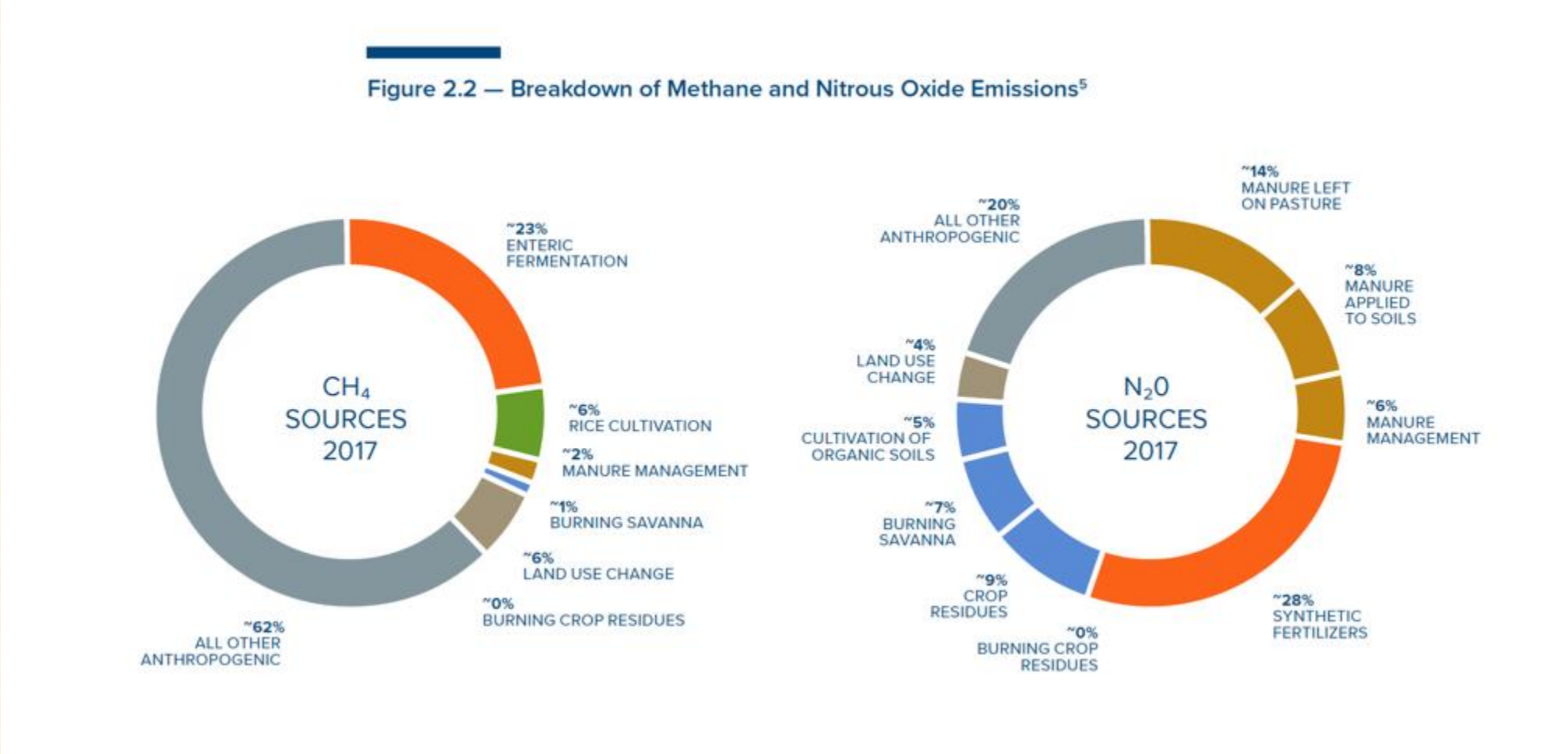
Emissions from Agriculture

Our Food System Causes 34% of Emissions

Category	Emissions Source	% of Total
Land use change	Mostly deforestation	11%
Agriculture	Crop and livestock production	14%
Supply chain	Transport, processing, packaging, retail, consumption	7%
End of life	Solid waste and wastewater	3%
All other emissions	Everything else	65%

IPCC (2019) *Climate Change and Land Summary for Policymakers*
Crippa (2021) "Food systems are responsible for a third of global anthropogenic GHG emissions"

38% of Methane, 80% of Nitrous Oxide



Drawdown (2020) *Farming Our Way Out of the Climate Crisis*

The Overflowing Sink

Toensmeier (2020) *Farming Our Way Out of the Climate Crisis*

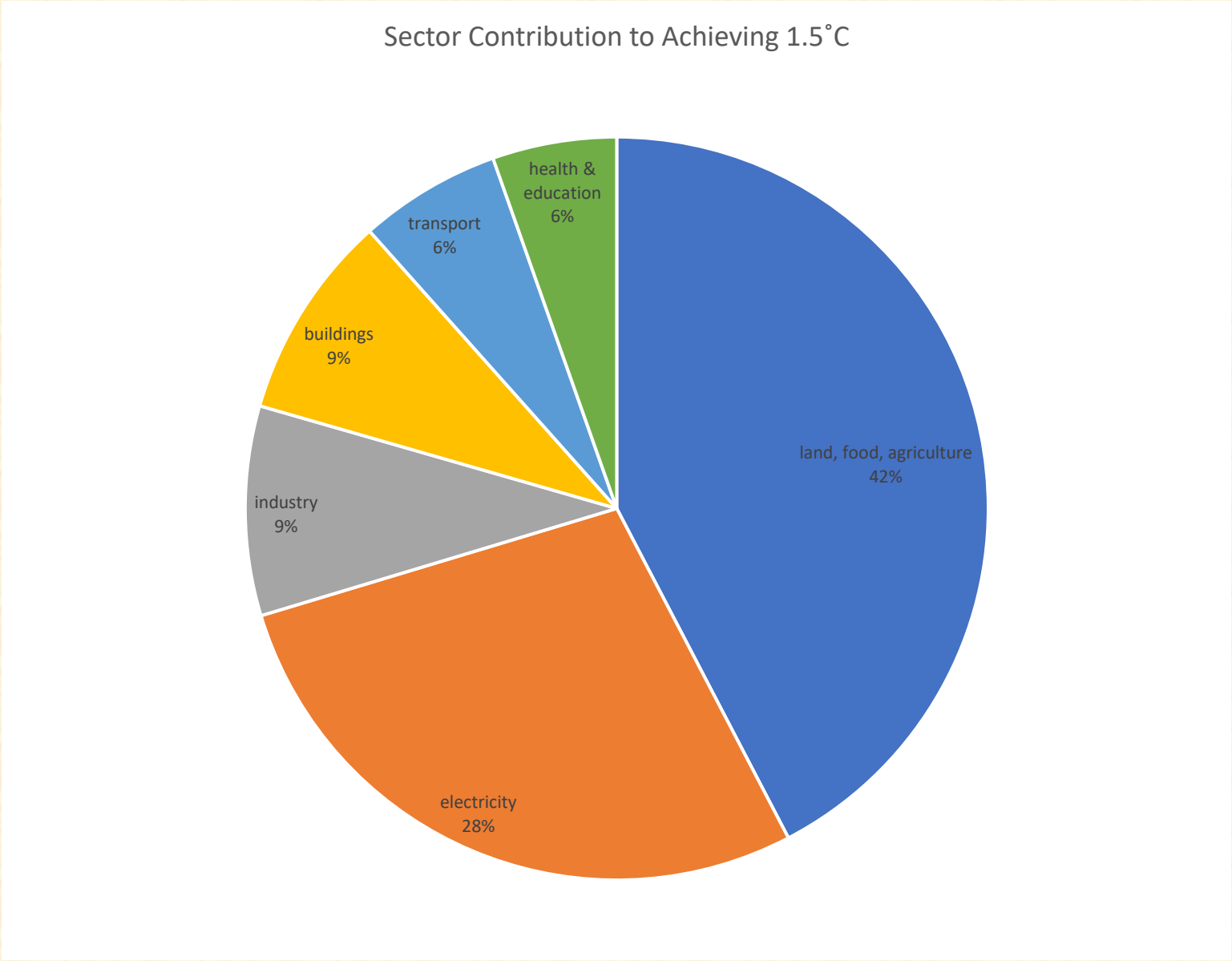
Food System Mitigation

- Reducing food waste
- Changing diets in wealthy countries
- Growing more food on the land we have
- Reducing emissions from farming
- Sequestering carbon in soils and biomass
- Changes to the supply chain

Mitigation: Food System Contribution to a 1.5˚C World

farming and land use change 28% of emissions today

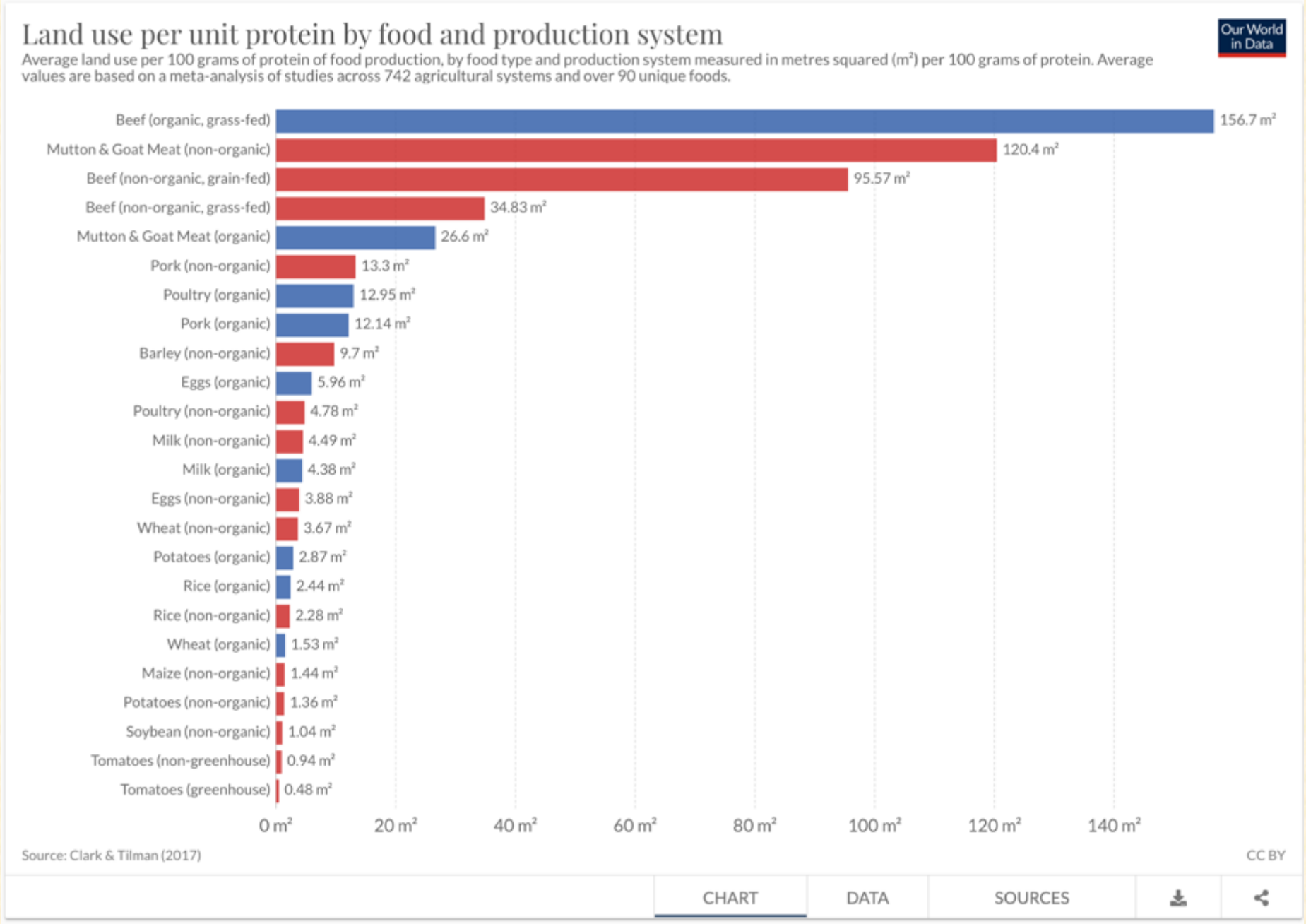
offers 42% of mitigation



Drawdown (2020) *Drawdown Review 2020*

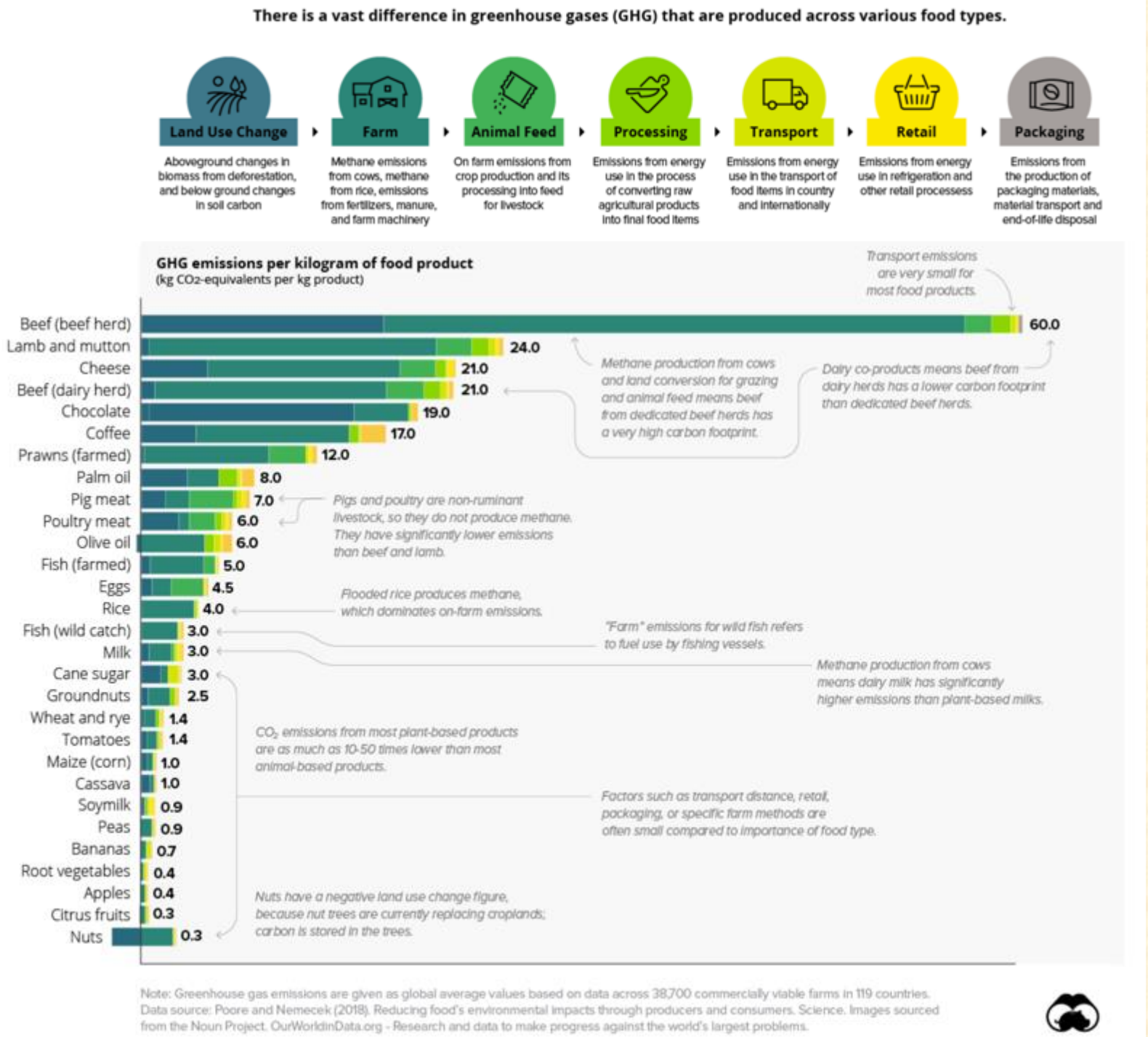
Not All Foods Have Equal Impact

Land Needed to Grow Protein



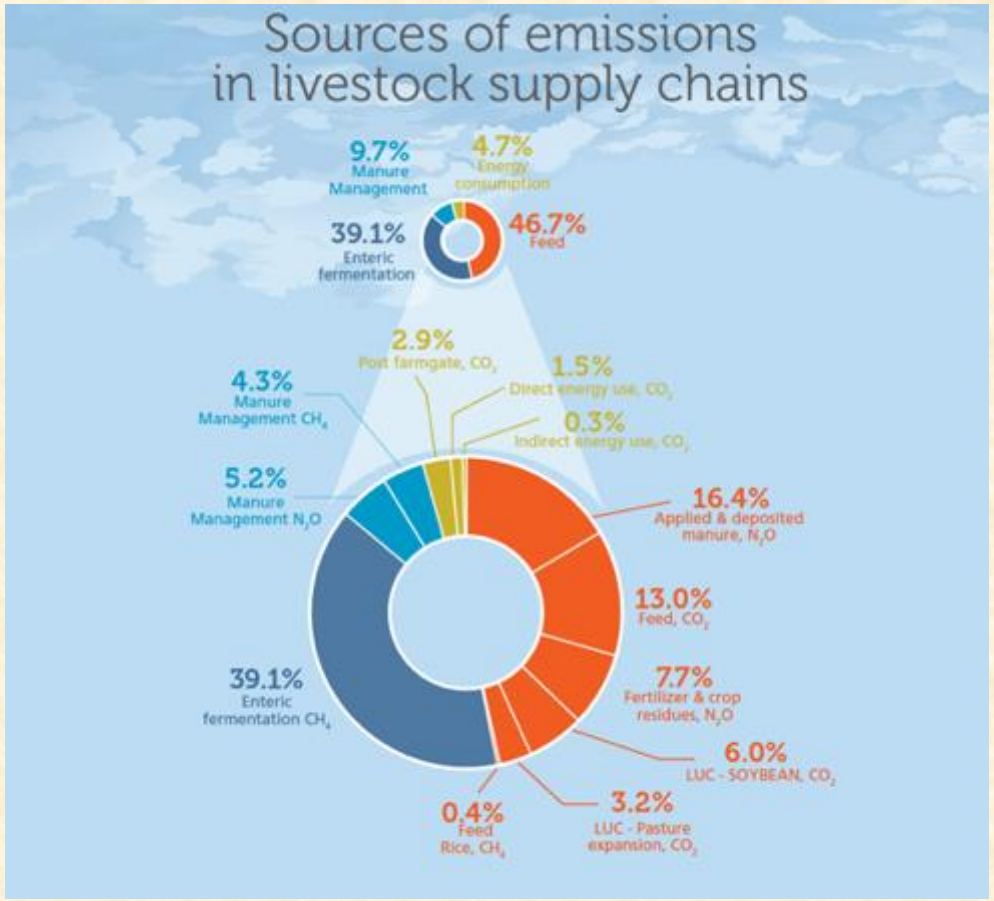
Emissions from Production

Neufeld (2020) “The carbon footprint of the food supply chain”

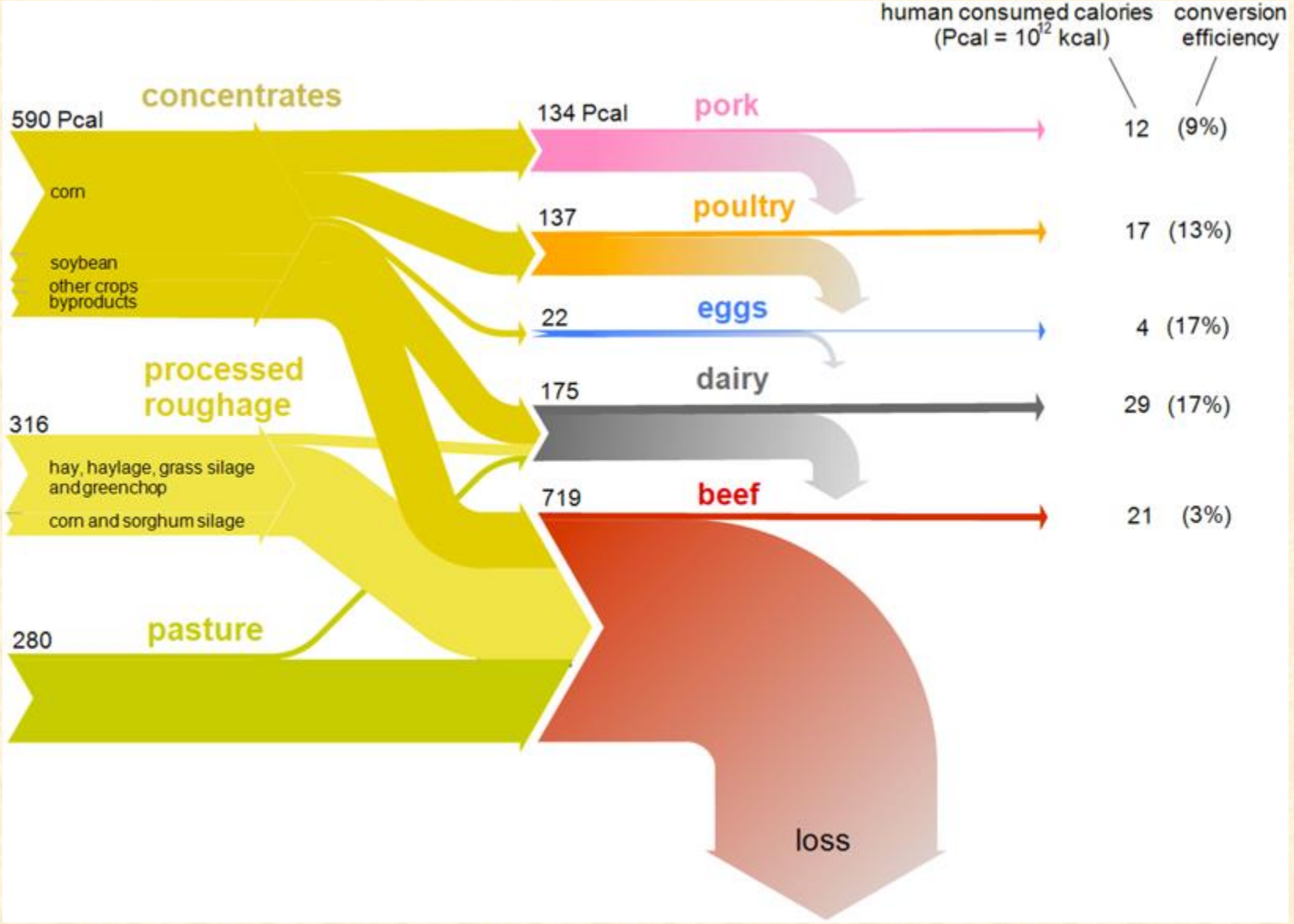


Livestock Issues

- 65% of farmland
- 33% of crops used as feed
- 10% of calories produced
- 80% of agriculture emissions
- Main driver of deforestation



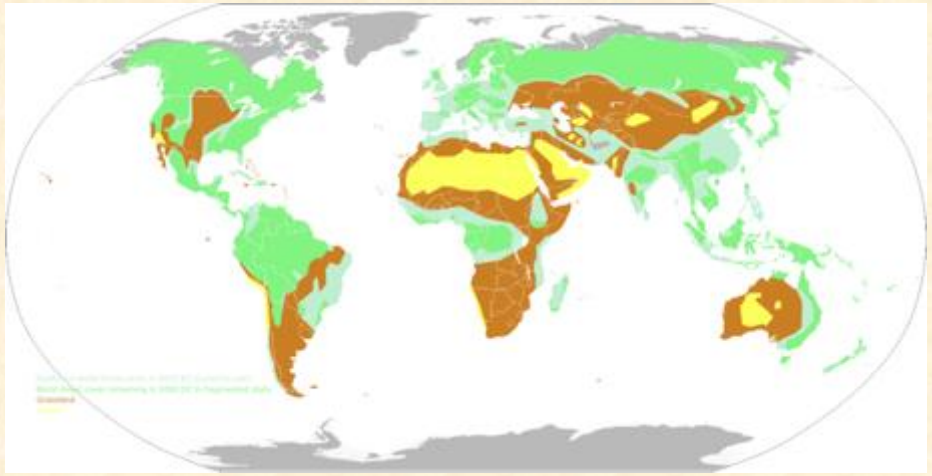
Lal (2012) “Climate change mitigation by managing the terrestrial biosphere”
Drawdown.org
Toensmeier (2016) *The Carbon Farming Solution*
Garnett (2017) *Grazed and Confused*
FAO (2016) *Livestock and Climate Change*



Shepon (2016) “Energy and protein feed-to-food conversion efficiencies in the US and potential food security gains from dietary changes”

Agroecological Advantages of Livestock

- Grassland represents 70% of farmland
- Livestock can be raised in places where crop production is difficult
  - too dry
  - too steep
  - too rocky
  - too remote
- Can eat things people can't and turn them into food
  - Crop residues
  - Food waste
  - Grass and tree leaves
- Can cycle nutrients to improve soil fertility



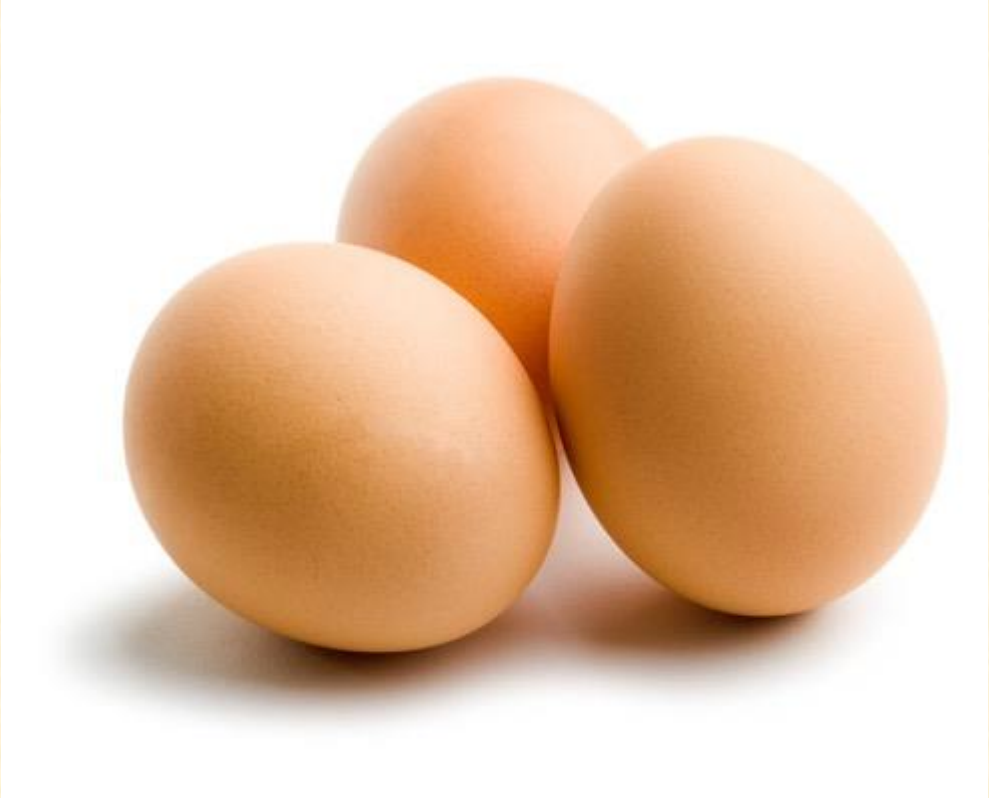
Toensmeier (2016) *The Carbon Farming Solution*
Garnett (2017) *Grazed and Confused*
FAO (2016) *Livestock and Climate Change*

Climate-Friendly Livestock Systems Exist

Toensmeier (2018) “How to make beef less terrible for the environment” Drawdown.org

Livestock On Leftovers

- Livestock eat only what people cannot
  - Grazing and tree leaves
  - Crop residues
  - Food waste
- Average of 21 g/day per person animal protein



Garnett et al (2017) *Grazed and confused? Ruminating on cattle, grazing systems, methane, nitrous oxide, the soil carbon sequestration question – and what it all means for greenhouse gas emissions.*
Van Zanten (2018) "Defining a land boundary for sustainable livestock consumption"

Reducing Deforestation

Food Waste Reduction

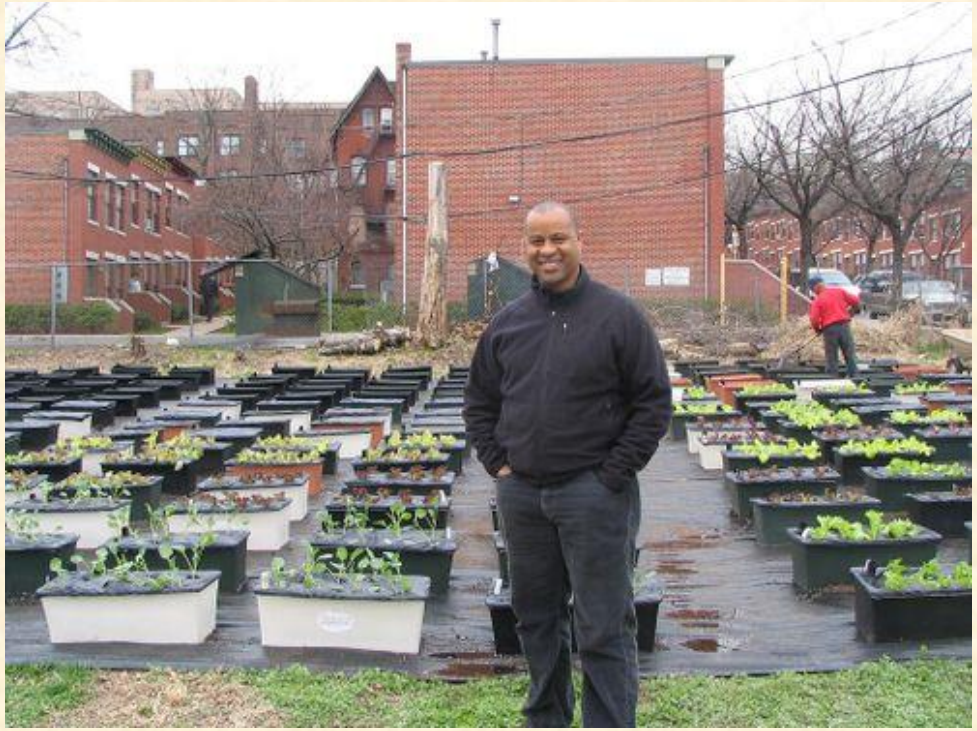

Over-consumption of animal products
is not a global problem.
60%
protein intake
from animal products
20%
protein intake
from animal products
FOOD CHOICE
IS A PRIVILEGE
ILRI
INTERNATIONAL
LIVESTOCK RESEARCH
INSTITUTE
CGIAR

Diet Change for Wealthy Countries

The EAT-*Lancet* Diet

Intensification

- Growing more on the farmland we have
  - And where no food is grown today
- *Can* reduce pressure on forests
- Many forms of intensification
  - Agrochemical
  - Agroecological

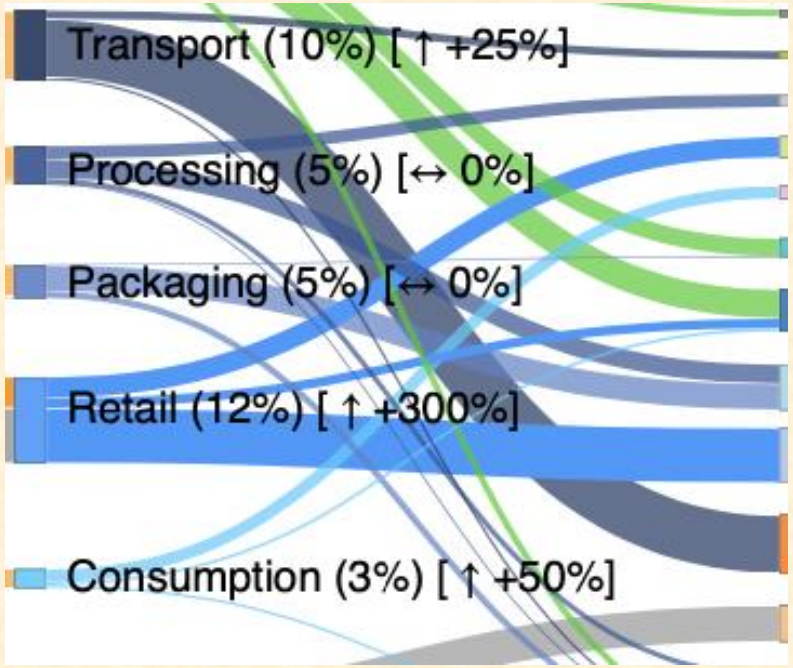


Supply Chain

transport

Some Supply Chain Strategies

- Refrigerants
- Sustainable sourcing
- Certification
- Electrify & switch to clean energy
- Optimize transportation



Vermeulen (2012) *Climate change and food systems*
Crippa (2021) "Food systems are responsible for a third of global anthropogenic GHG emissions"
Drawdown.org

Transport

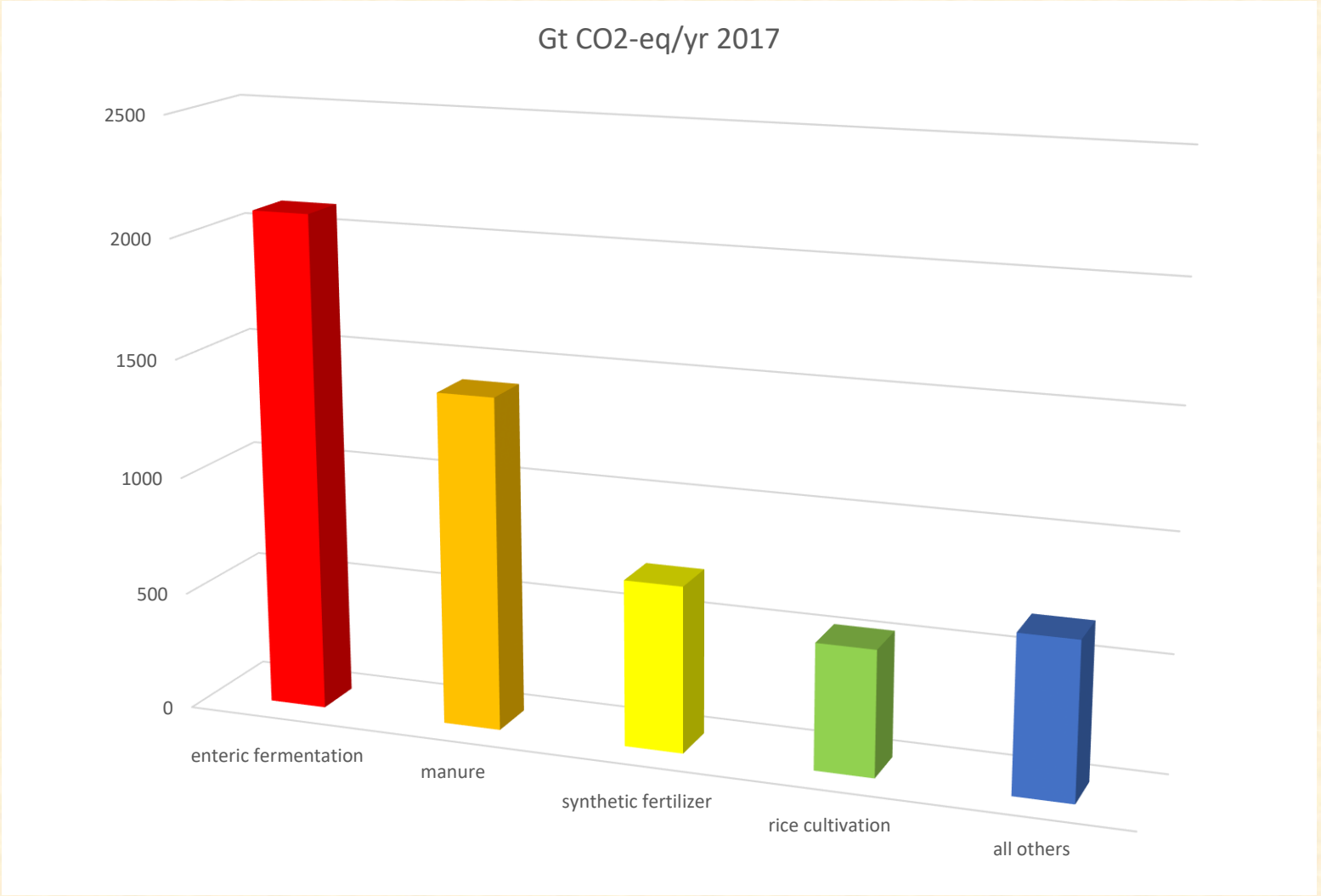
- 5% of total food system emissions
- local often ***worse*** because it increases driving
- Within 25 miles local often better
- Food hubs, better distribution

"Conversations in the Wasatch front: Food hubs and food security"

FCRN Foodsource (nd) *Food systems and greenhouse gas emissions*
Martinez (2010) *Local Food Systems*
Pelletier (2011) "Energy intensity of agriculture and food systems"
Mundler and Rumpus (2012) "The energy efficiency of local food systems"
Crippa (2021) "Food systems are responsible for a third of global anthropogenic GHG emissions"

Reducing Emissions from Production

Sources of Agricultural Emissions



Toensmeier (2020) *Farming Our Way Out of the Climate Crisis*

Reducing Agricultural Emissions

Enteric fermentation	Manure	Synthetic fertilizers	Rice Methane	Others
• Concentrate feeds • Feed additives • Breeding & management • Improved forage quality • Tree fodder • *Brachiaria* grasses	• *Brachiaria* grasses • Nitrification inhibitors • Restore degraded pastures • Improved manure management • Feed additives • Timing of spreading on fields • Tree fodder • Biodigestors	• Nutrient management • Compost • Green manures • Nitrogen fixing trees • Livestock integration	• Water management • Aerobic cultivars • Nutrient management • Reduced tillage	• Reduce tillage • Reduce residue burning • Savanna fire management • Rewetting of peat soils

Toensmeier (2020) *Farming Our Way Out of the Climate Crisis*

Sequestering Carbon

Sequestration

- Photosynthesis:
  - CO2 → carbohydrates in plants, becomes biomass
- 10-40% exuded from roots within 1 hour
  - Kumar et. al., "Plant Roots and Carbon Sequestration"
- Much biomass becomes organic matter over time
  - Root and leaf decomposition
  - Much also re-released as CO2

Drawdown (2020) *Farming Our Way Out of the Climate Crisis*

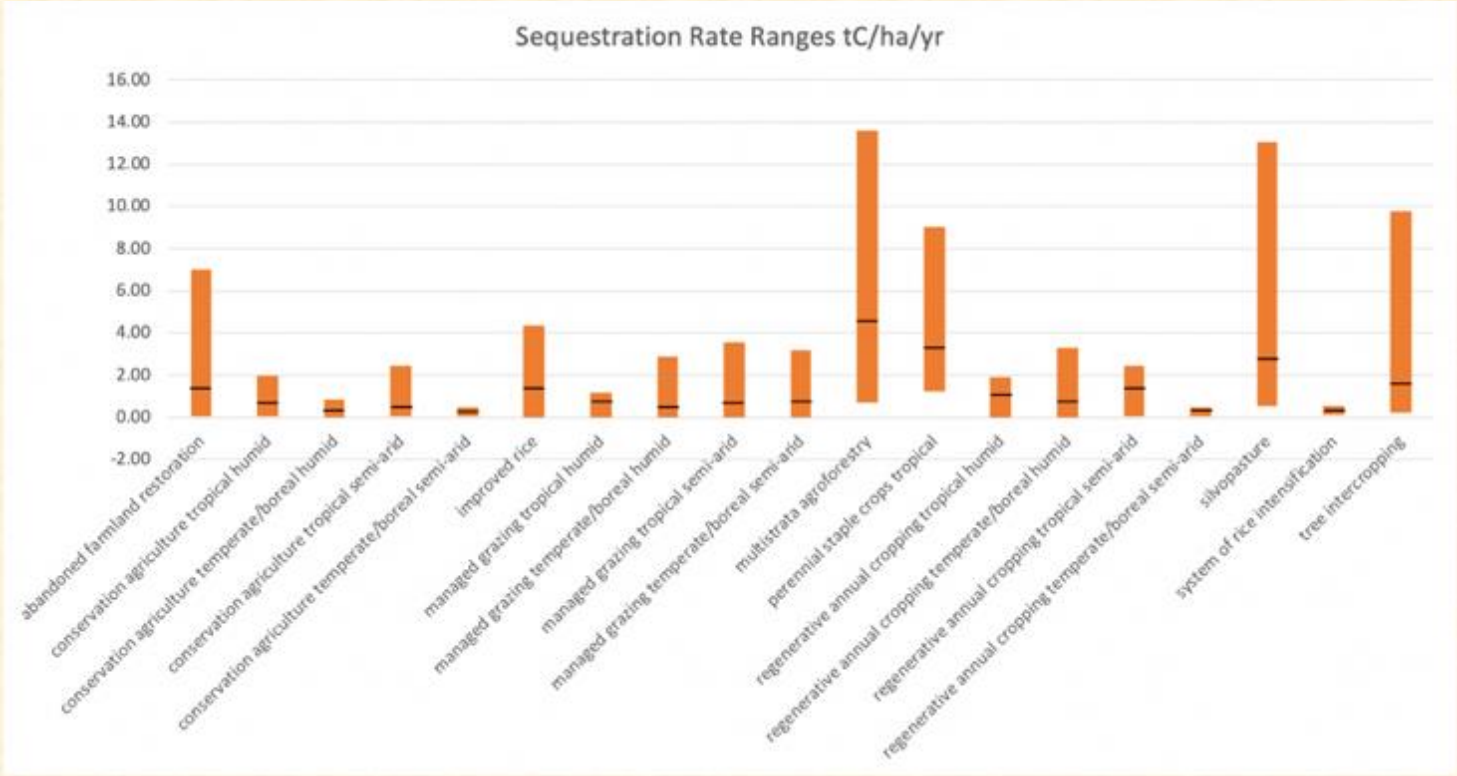
Increased Soil Organic Matter

- Better water-holding capacity
- Better infiltration of storms
- Soil carbon sequestration
  - Increased methane sink
- How?
  - Apply compost
  - Reduce tillage
  - Use cover crops
  - Perennialize

- 9,888 gallons per acre
  - For each 1% SOM gain *estimated*

Rates Vary by Practice and Climate

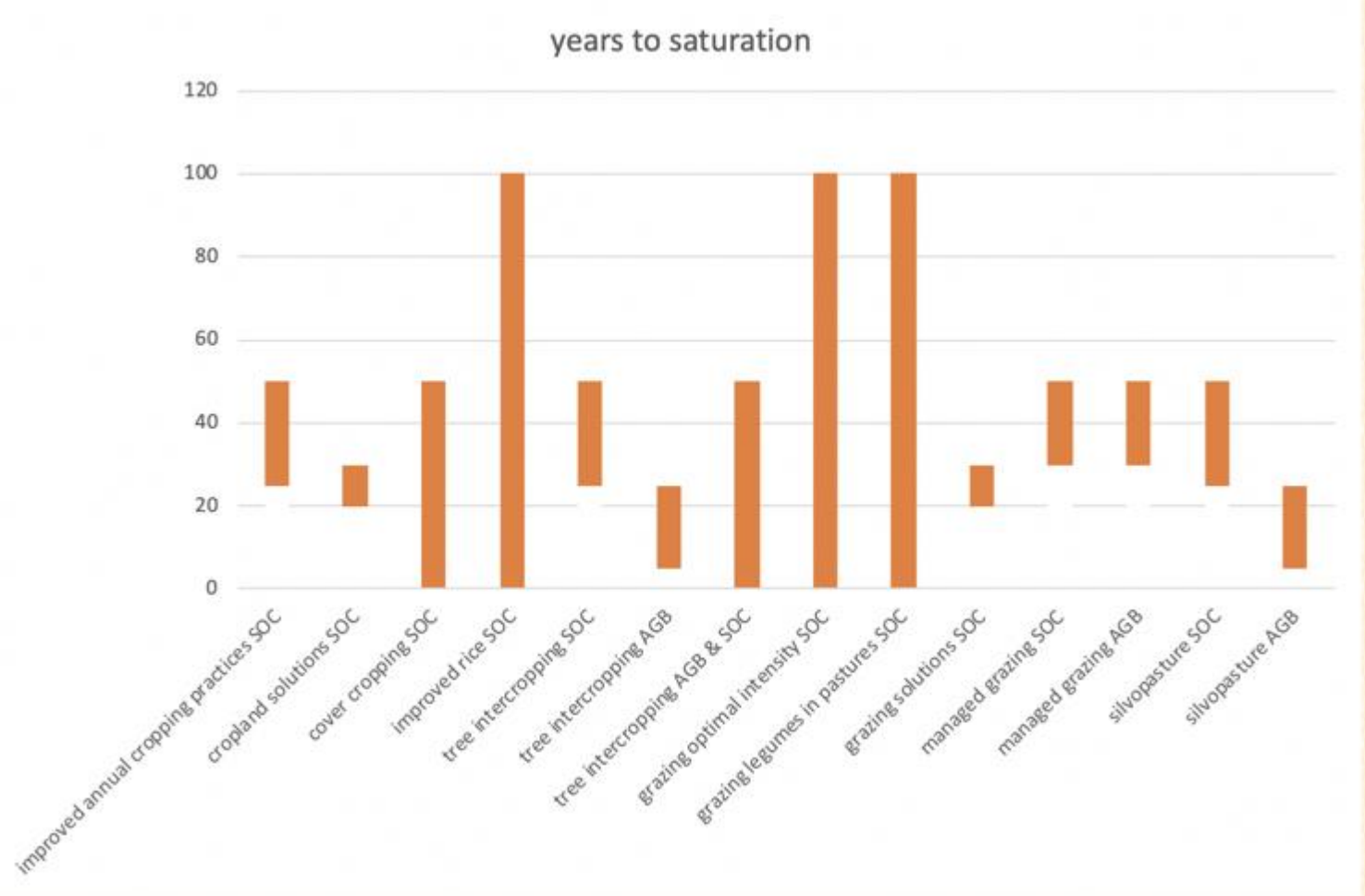
- Climate justice:
  - Did least to cause problem, most impacted
  - Highest rates limited to tropics
  - Lowest cost



Drawdown (2020) *Farming Our Way Out of the Climate Crisis*

Drawbacks

- Not unlimited
  - Generally 20-50 years to slowdown
- Not permanent
- Reversible
  - Change in farming
  - Change in climate



Drawdown (2020) *Farming Our Way Out of the Climate Crisis*

Sample Systems

Improved Cropping: Nutrient Management

Low-Methane Rice: System of Rice Intensification

Improved Cropping: Cover Cropping

Grazing Systems: Al-Hima

Silvopasture: Intensive Silvopasture

- Colombia leading the way
- Outstanding carbon sequestration
- *Reduced emissions from cattle*
- Huge productivity gains permit reforestation of pastureland

Toensmeier (2018) “How to make beef less terrible for the environment”
Toensmeier (2016) *The Carbon Farming Solution*

Trees on Cropland:
Farmer-Managed Natural Regeneration

- From 1980s in Niger
  - Today 50% of cropland in Niger
- 7 million hectares total
  - About the size of Missouri
- Outstanding carbon sequestration
- Adaptation

evergreening.org (nd) “Farmer-Managed Natural Regeneration”

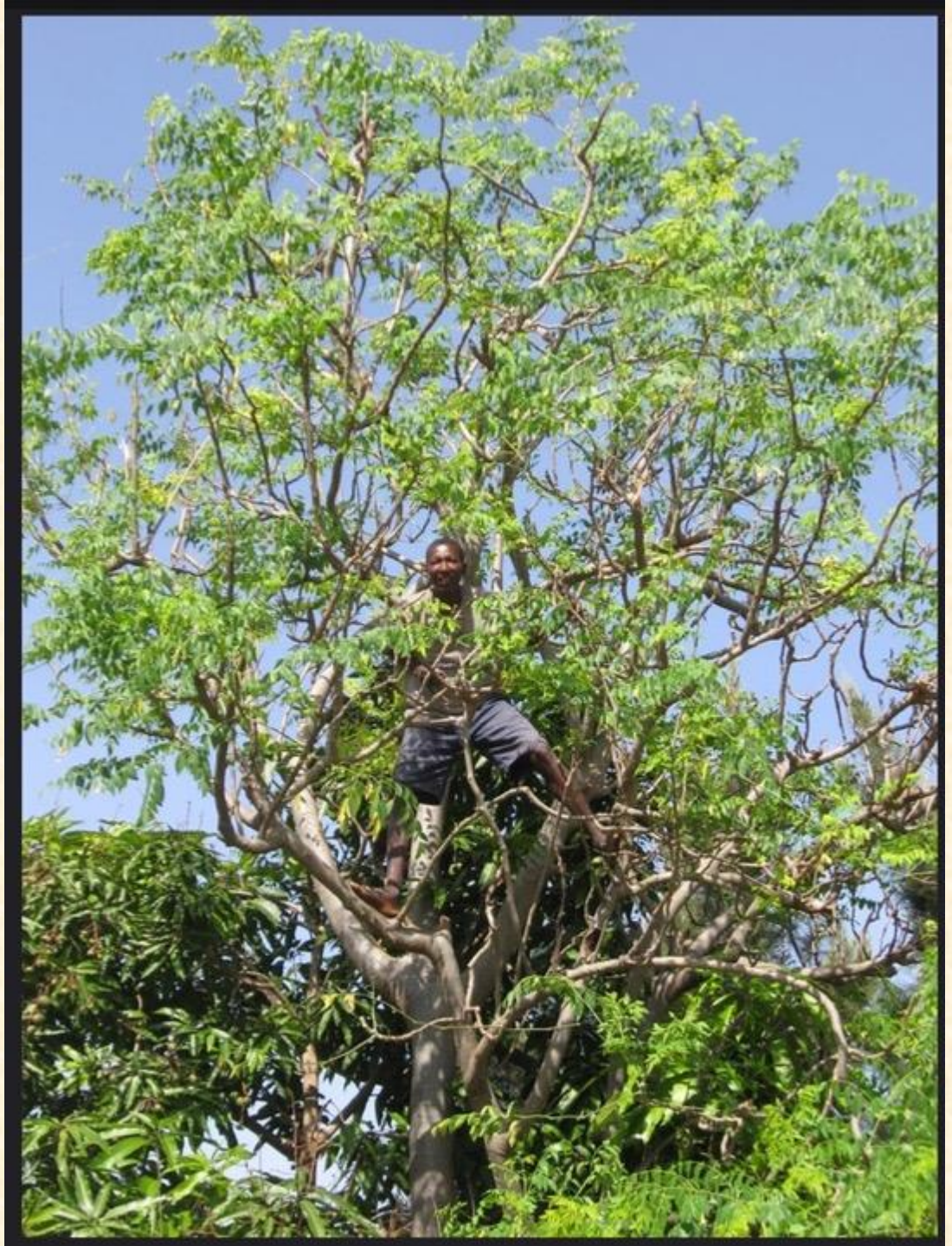
Trees on Cropland: Mechanized Tree Intercropping

- China 1980s
- Now France taking the lead
- Outstanding carbon sequestration
- Timber and food on less land

Toensmeier (2016) *The Carbon Farming Solution*

Perennial Crops: Trees with Edible Leaves

- 100+ cultivated species
- Mostly tropical
- The *most* nutritious
- Carbon sequestration
- Climate adaptation



Toensmeier et al (2020) “Perennial vegetables: A neglected resource for biodiversity, carbon sequestration, and nutrition”

Policy Challenges

- Carbon offsets: sequestration should not be used to offset emissions on a global scale
- Carbon sequestration critical ***if*** goes along with decarbonization

Stabinky (2020) “Nature-based solutions or nature based seductions”?