Climate Change

Food and Land Use

Presentation Overview

- Overview of issues
- Impacts of climate change on food systems (availability & access)
- Adaptation measures
- Impacts of food systems on the climate
- Mitigation, challenges and opportunities
- Mitigation, adaptation, food security and land use:
- Synergies, trade-offs and co-benefits
- Enabling conditions
- Future Challenges

Overview

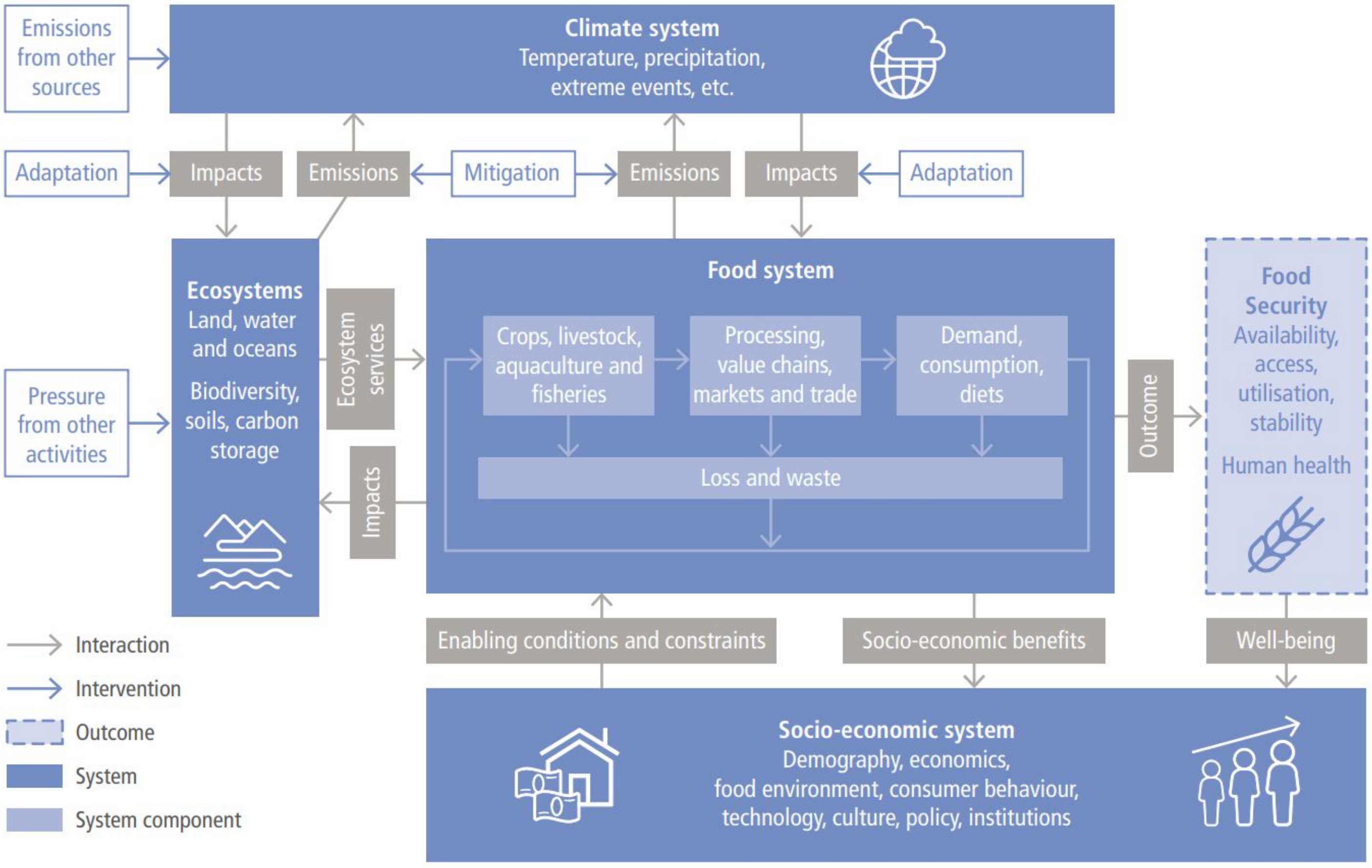


Figure 5.1 | Interlinkages between the climate system, food system, ecosystems (land, water and oceans) and socio-economic system. These systems operate at multiple scales, both global and regional. Food security is an outcome of the food system leading to human well-being, which is also indirectly linked with climate and ecosystems through the socio-economic system. Adaptation measures can help to reduce negative impacts of climate change on the food system and ecosystems. Mitigation measures can reduce GHG emissions coming from the food system and ecosystems.

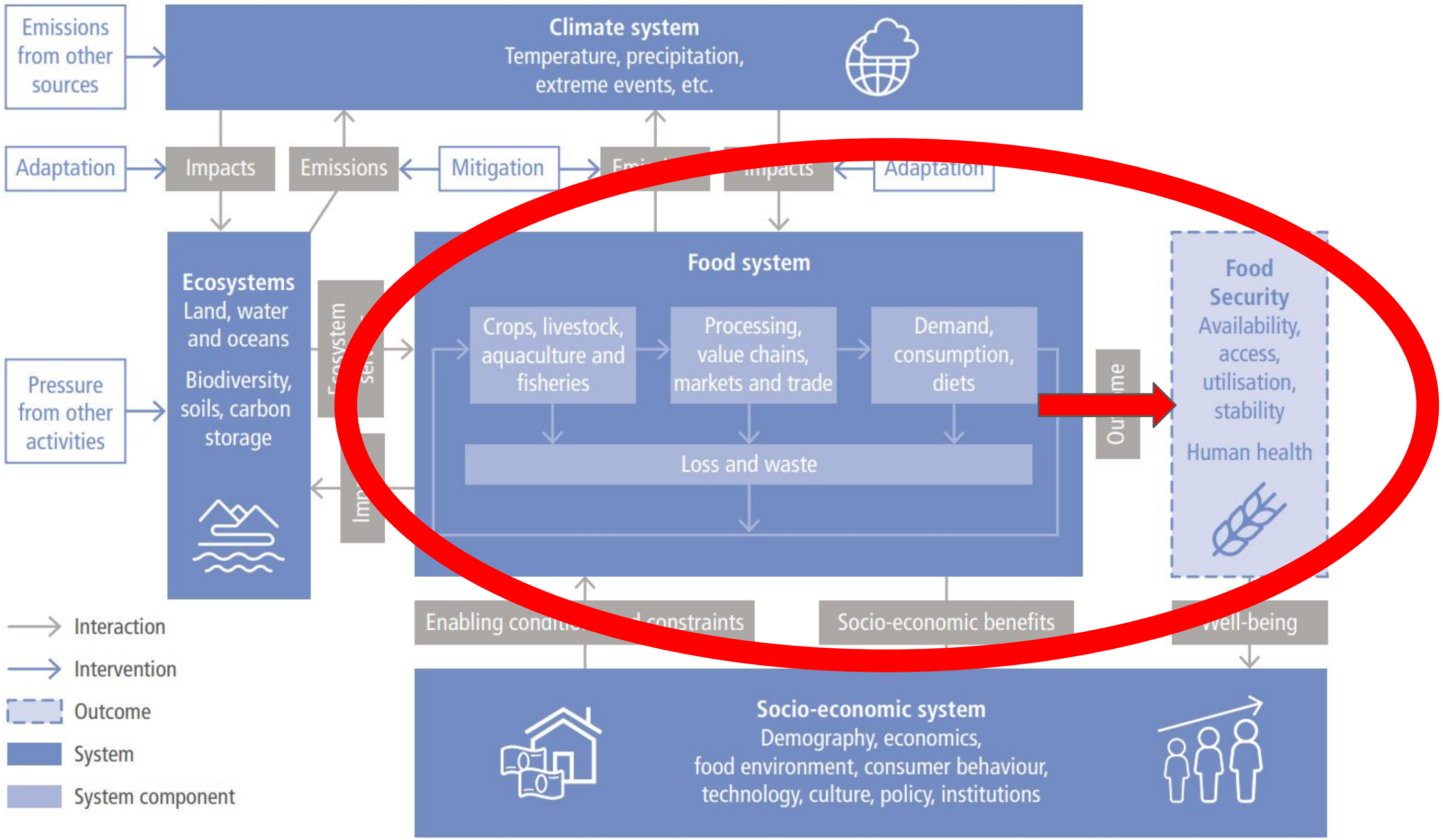
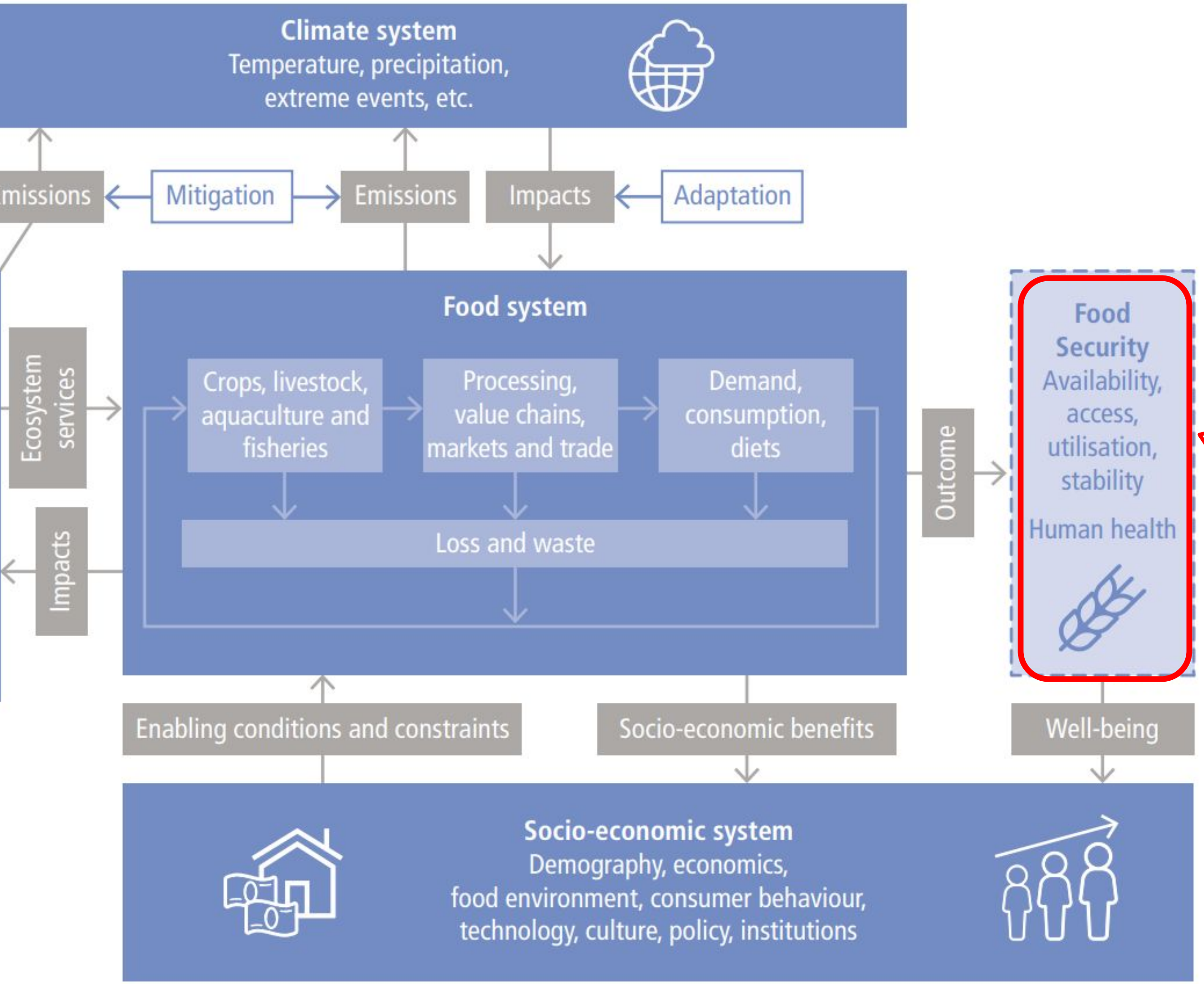


Figure 5.1 | Interlinkages between the climate system, food system, ecosystems (land, water and oceans) and socio-economic system. These systems operate at multiple scales, both global and regional. Food security is an outcome of the food system leading to human well-being, which is also indirectly linked with climate and ecosystems through the socio-economic system. Adaptation measures can help to reduce negative impacts of climate change on the food system and ecosystems. Mitigation measures can reduce GHG emissions coming from the food system and ecosystems.



when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life

Four dimensions of food security

Availability
- domestic prd
- food imports
- food stocks
- food aid

Access
- tpt and mkt facilities
- poverty
- purchasing power
- food dist

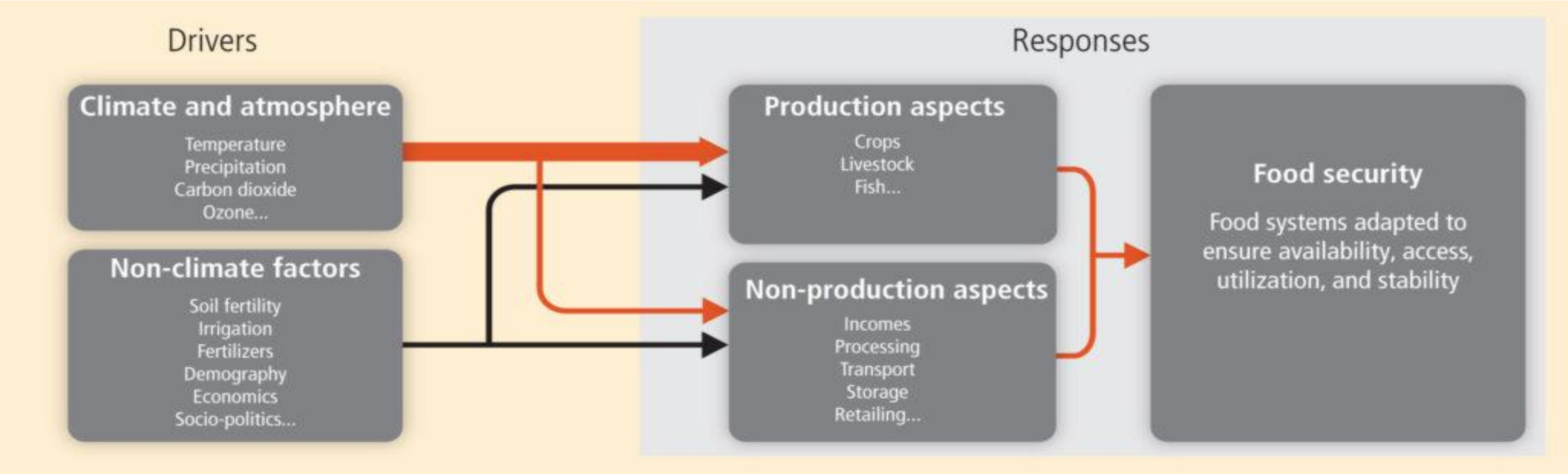
Utilisation
- Care and feeding
- Food safety
- Quality of $H2O$
- Nutrition

Stability
- Weather variability
- Pol and econ factors
- Px fluctuations

Climate Change
&
Equity of food

Climate Change
&
Gender dimensions of food security

Impacts of climate change on food systems

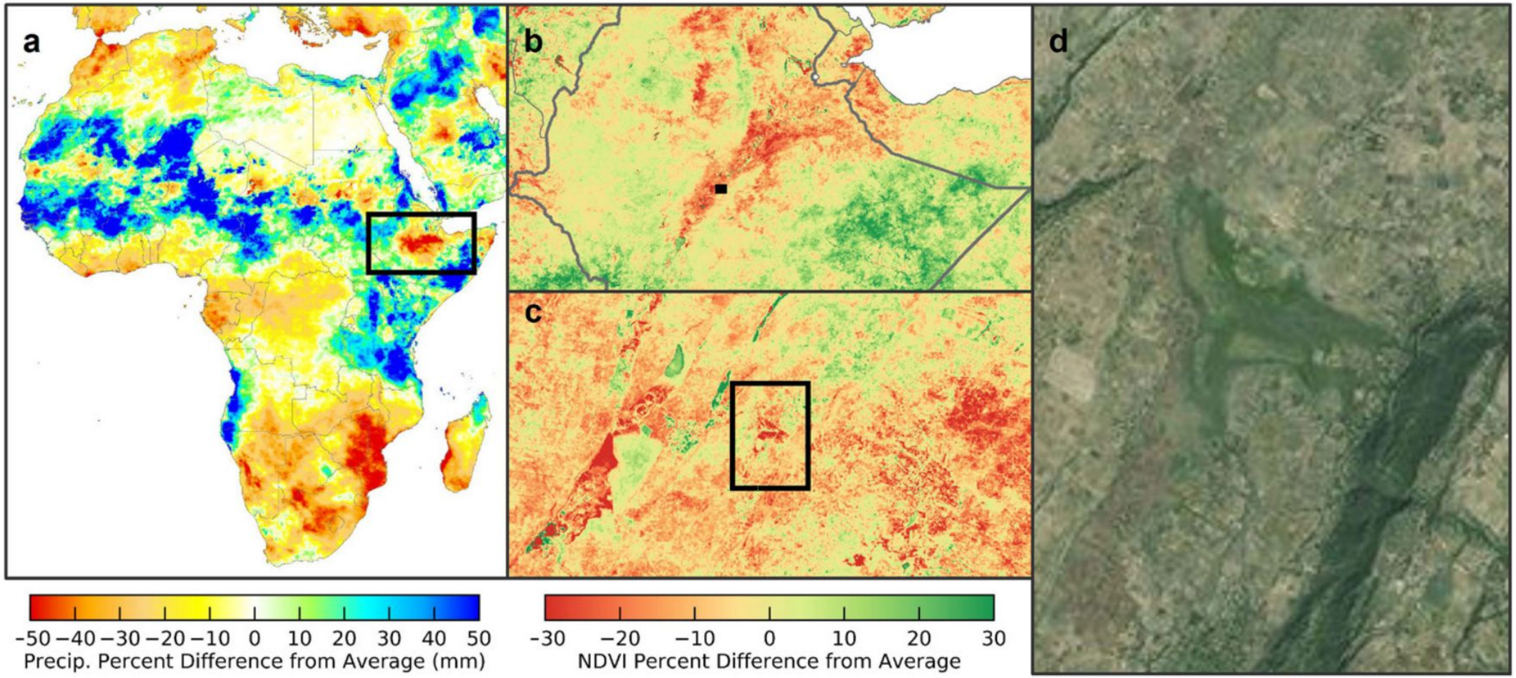


Two routes climate change impacts food security

Indirect impact (water quality, pests)

Direct impact (temperature, precipitation)

Precipitation anomaly and vegetation response in eastern Africa



Climate change impact on food availability

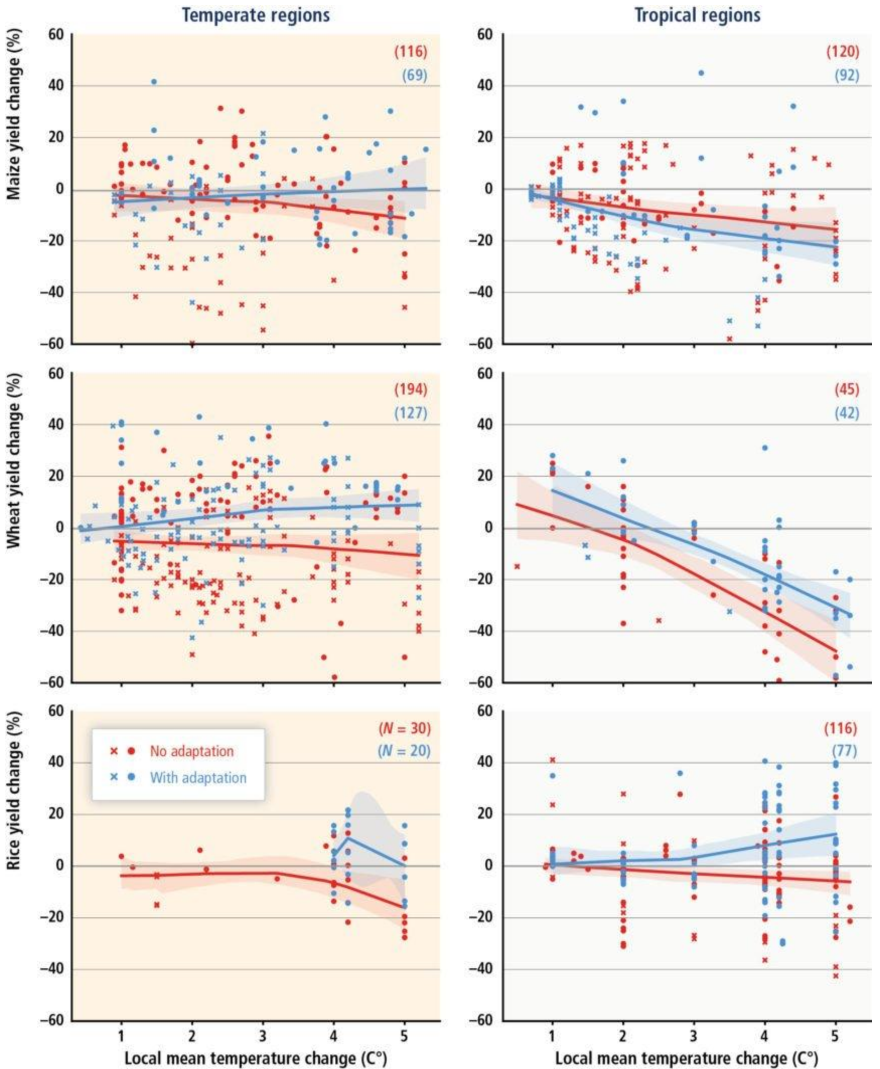
Impacts on crops

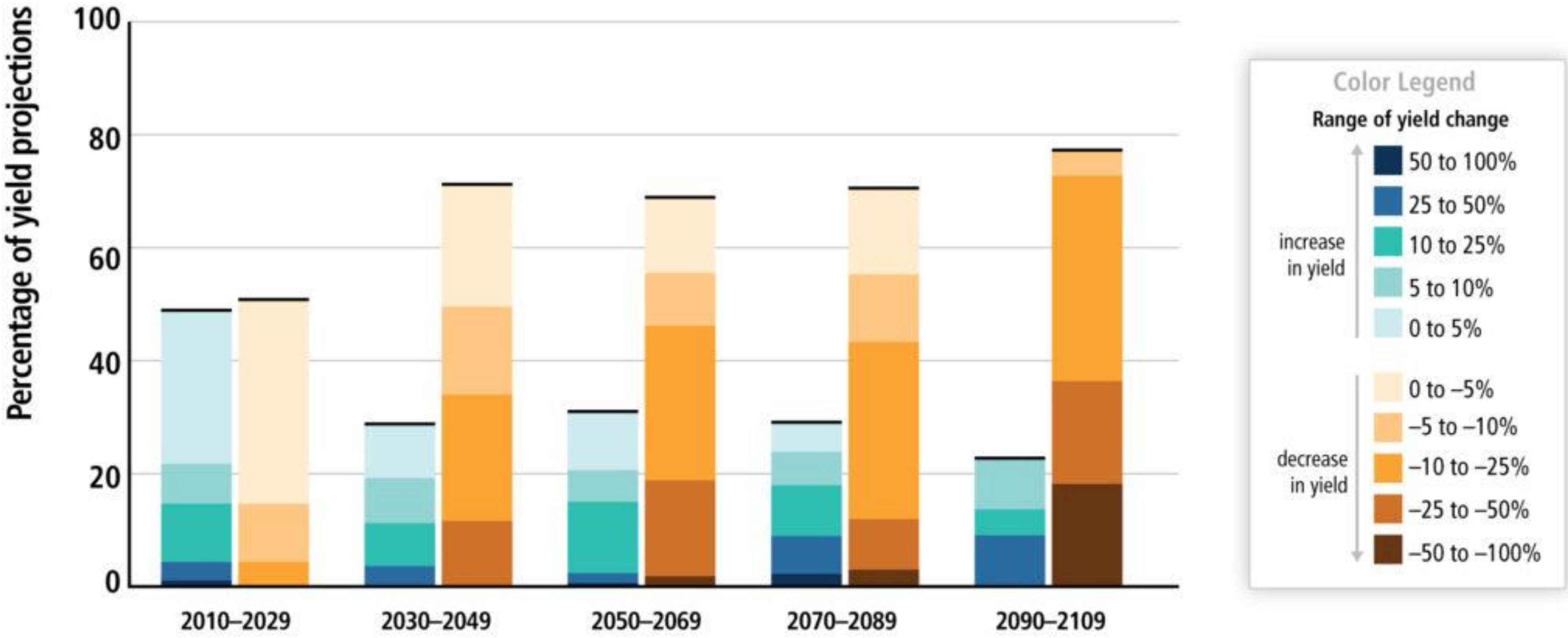
- Climate change between 1981 and 2010 has decreased global mean yields of maize, wheat, and soybeans by 4.1, 1.8 and 4.5%, respectively, relative to pre industrial climate, even when CO2 fertilisation and agronomic adjustments are considered.
- But everything depends on the territory.

Part of the world	Impact
Australia	Declines in rainfall and rising daily maximum temperatures caused water-limited yield potential to decline by 27% from 1990 to 2015, even though elevated atmospheric CO_2 concentrations had a positive effect
Asia	China: Rice yield increases have been found in 80`s and 2000(reason: structural adjustment, technological progress, government policies). Wheat growth and yield in different climate zones of China from 1981–2009 found that impacts were positive in northern China and negative in southern China. India: India have found that warming has reduced wheat yields by 5.2% from 1981 to 2009 Pakistan: From 1980 to 2014, spring maize growing periods have shifted an average of 4.6 days per decade earlier, while sowing of autumn maize has been delayed 3.0 days per decade Hindu-Kush region: The region is experiencing an increase in extremes, with farmers facing more frequent floods as well as prolonged droughts
South America	Altered the timing of planting and soil management strategies. In Argentina, there has also been an increase in yield variability of maize and soybeans.
Africa	Maize, wheat, sorghum, and fruit crops (e.g. mangoes), have decreased across Africa. Increased level of malnutrition.
Europe	Climate trends are affecting European crop yields, with long-term temperature and precipitation trends since 1989 reducing wheat and barley yields by 2.5% and 3.8%, respectively, and having slightly increased maize and sugar beet yields. In Italy drying trend leads to yield declines of 5%. In the Czech Republic, a study documented positive long-term impacts of recent warming on yields of fruiting vegetables (cucumbers and tomatoes) from 4.9 to 12%

Projected impacts on crops

- Different methods consistently showed negative temperature impacts on crop yield at the global scale
- Impacts on crops grown in the tropics are projected to be more negative than in mid – to high-latitudes
- The effect of increased CO2 on vegetables is mostly beneficial for production, but may alter internal product quality
- Impacts will vary depending on CO2 concentrations, fertility levels, and region
- A trend in increased variation is also observed





Percentage of yield projections
100
80
60
40
20
0
2010–2029
2030–2049
2050–2069
2070–2089
2090–2109
Color Legend
Range of yield change
increase in yield
50 to 100%
25 to 50%
10 to 25%
5 to 10%
0 to 5%
decrease in yield
0 to –5%
–5 to –10%
–10 to –25%
–25 to –50%
–50 to –100%

Impacts on livestock

Increase of temperature

Water
Increase water consumption 2 to 3 times

Forage
Decrease nutrient availability
Increase herbage growth on C4 species (30°C–35°C)
Decrease feed intake and efficiency of feed conversion

Production
High producing dairy cows decrease milk production
Meat production in ruminants decreases because of a reduction in body size, carcass weight, and fat thickness

Reproduction
Decreases reproduction of cows, pigs, and poultry of both sexes
Reduce reproduction efficiency on hens and consequently egg production

Health
May induce high mortality in grazing cattle
New diseases may affect livestock immunity
Prolonged high temperature may affect livestock health (e.g. Protein and lipid metabolism, liver functionality)

Increase of CO_2

Forage
Changes in herbage growth (more effect on C3 species)
Decreases forage quality (more effect on C3 species)
Positive effects on plants:
– Partial stomata closure
– Reduce transpiration
– Improve water-use efficiency

Forage
Affect composition of pasture by:
– Shifting of seasonal pattern
– Changing optimal growth rate
– Changing availability of water

Precipitation variation

Diseases
Increases:
– Pathogens
– Parasites
– Disease spreading
– Disease transmission
– New diseases
– Outbreak of severe disease
– Spreading of vector-borne diseases

Forage
Long dry seasons decrease:
– Forage quality
– Forage growth
– Biodiversity

Floods change:
– Form and structure of roots
– Leaf growth rate

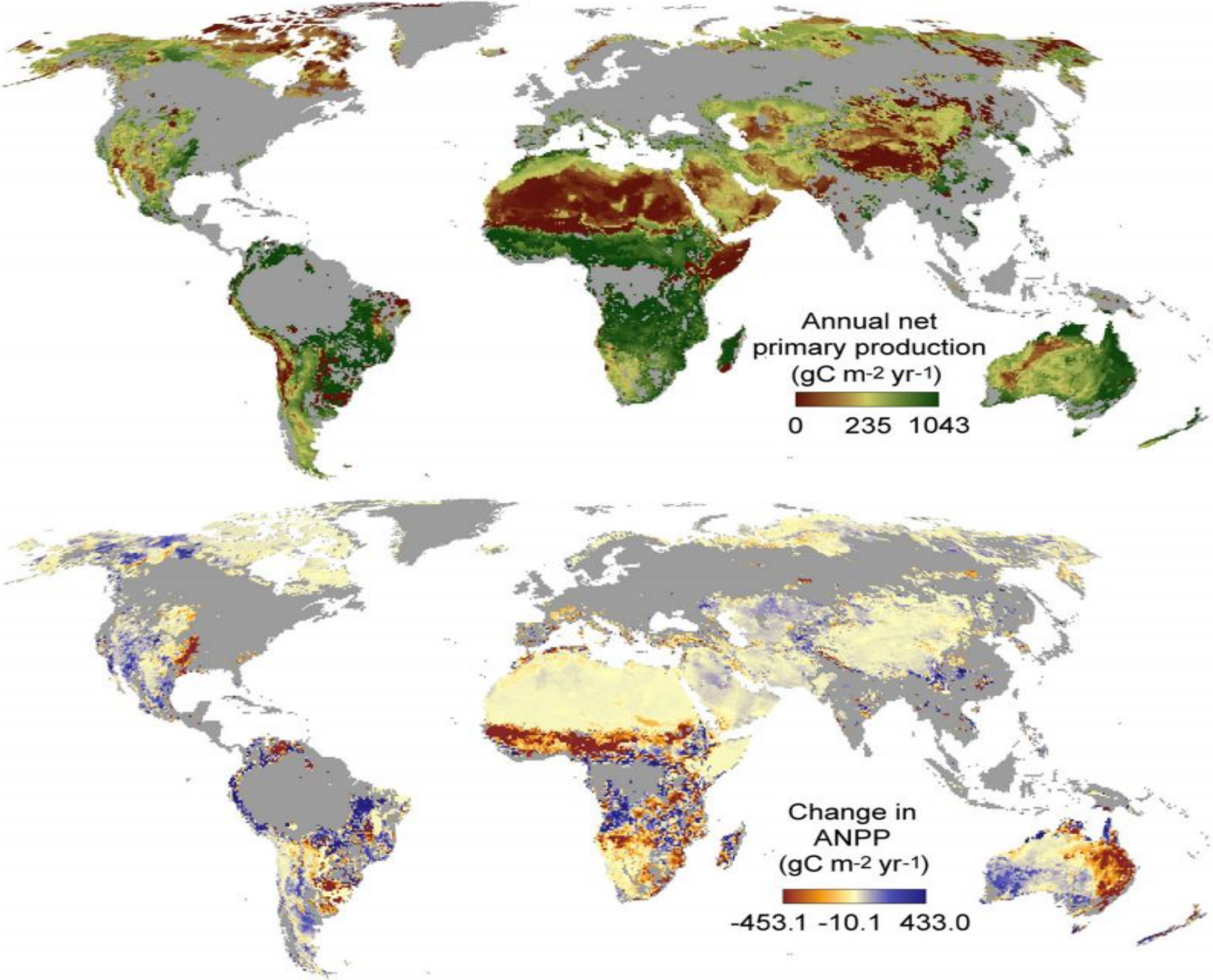
Projected impacts on livestock

- Projected impacts on grazing systems include changes in herbage growth and changes in the composition of pastures and in herbage quality
- Identified temperature 35°C is a critical threshold for rangeland vegetation and heat tolerance in some livestock species.

Effects on livestock

Increased water and temperature stress → higher morbidity, mortality and lower fertility.

Climate impact on crops and pastures → reduction in availability and quality of food


Annual net primary production (gC m-2 yr-1)
0 235 1043
Change in ANPP (gC m-2 yr-1)
-453.1 -10.1 433.0

Impacts on pests, diseases and pollinators

There are some biological and ecological mechanisms by which climate change can affect food production (changes in vectors and distributions of pests; host susceptibility; etc.)

About 50% of insects, which are often pests or disease vectors, will change ranges by about 50% by 2100 under current GHG emissions trajectories

Impacts on pests, diseases and pollinators

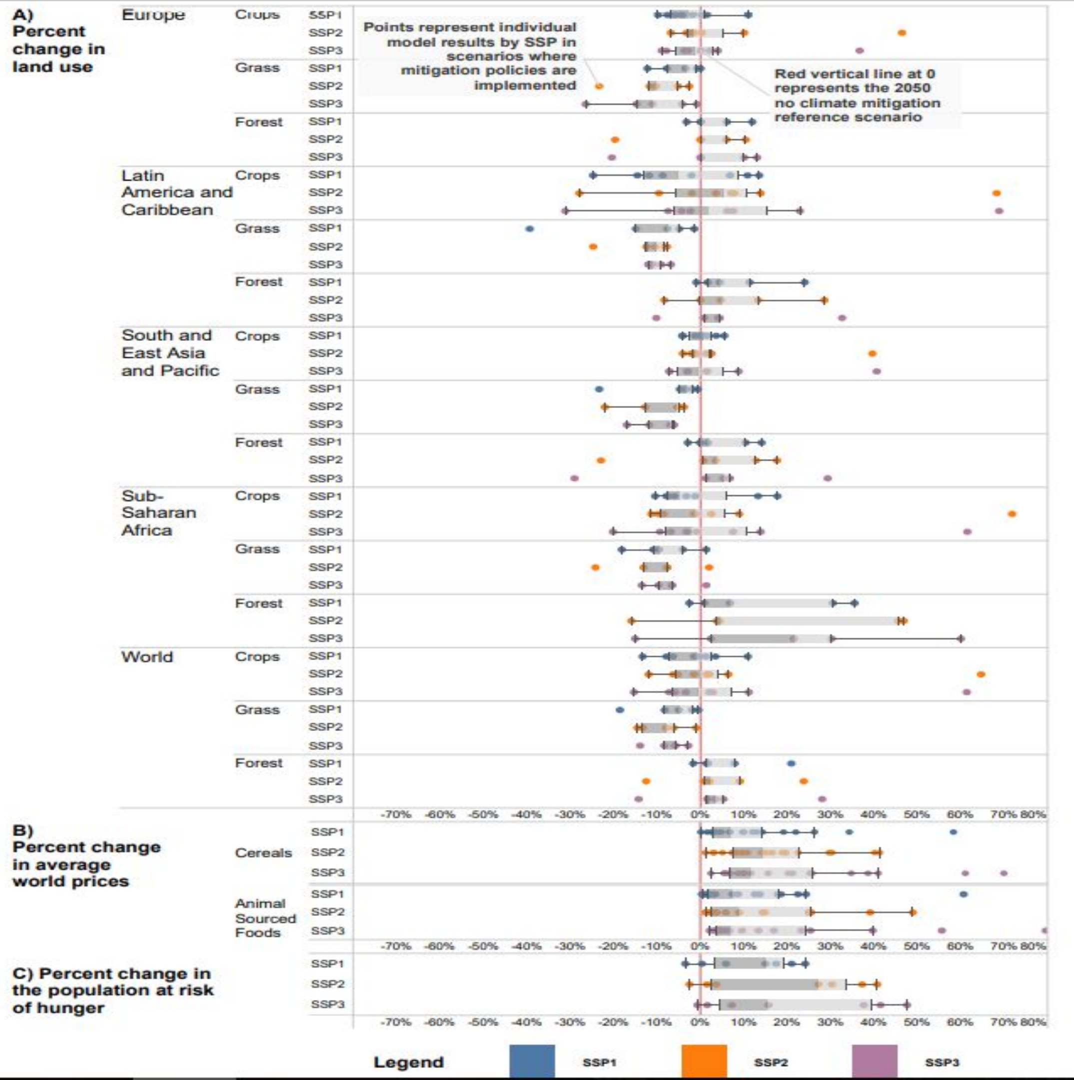
- Pollinator-dependent crops contribute up to 35% of global crop production volume and are important contributors to healthy human diets and nutrition

Threats to pollinators:

- Changed flowering times of the plants
- Pathogens affecting pollinators
- The increase in atmospheric CO_2

Climate change impacts on access

Impact on prices



Impacts on food safety and human health

- The activity of mycotoxin-producing fungi
- Heavy rainfall and floods causing contamination of pastures with enteric microbes (like Salmonella)
- Degradation and spoilage of products in storage and transport
- Foodborne pathogens are likely to increase through multiple mechanisms

Remember that everything depends on local conditions

Food quality

There are two main routes by which food quality may change:

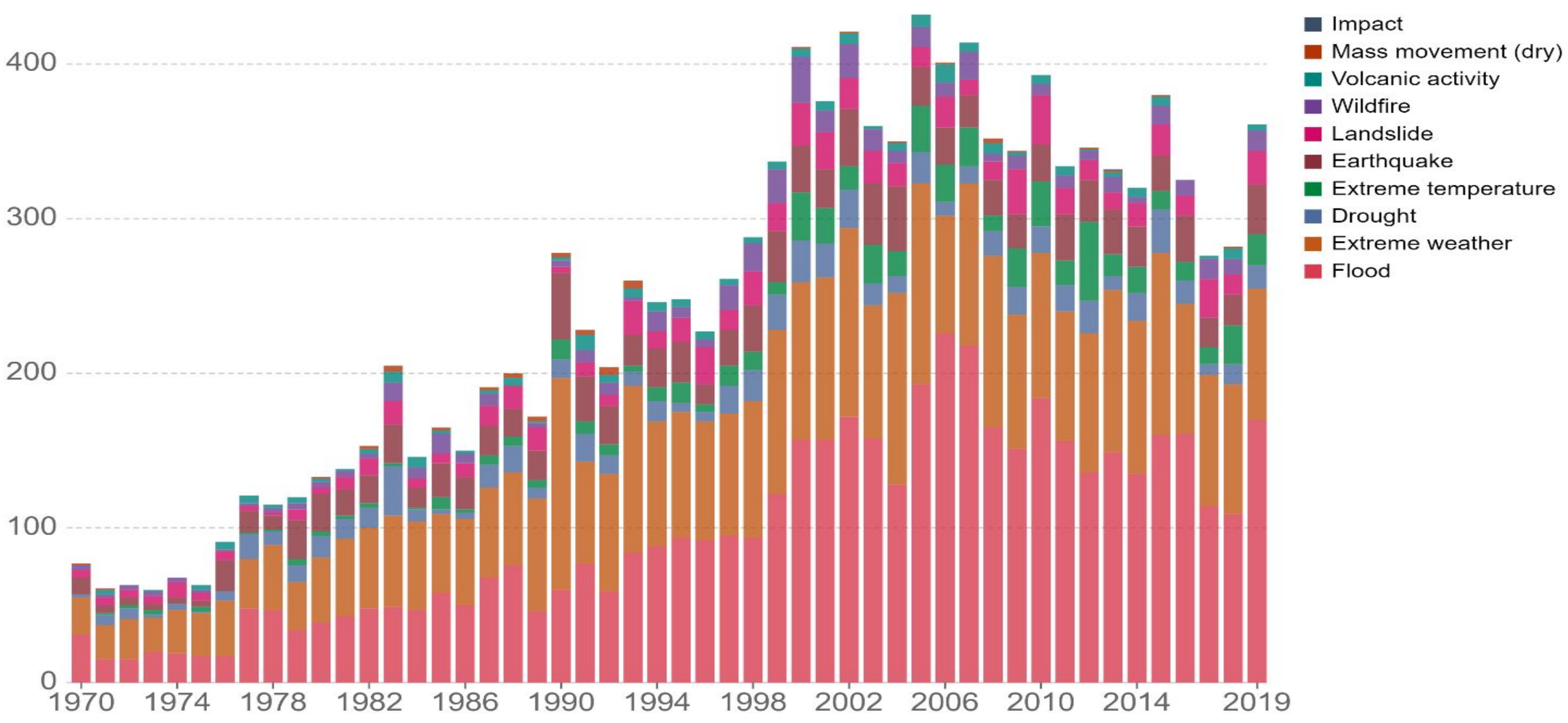
- First, the direct effects of climate change on plant and animal biology, such as through changing temperatures changing the basic metabolism of plants.
- Secondly, by increasing carbon dioxide's effect on biology through CO2 fertilization.

Food stability

- Food stability is related to people's ability to access and use food in a steady way, so that there are not intervening periods of hunger.
- But increasing extreme events associated with climate change can disrupt food stability
- Climate change will also influence food aids after different catastrophes

Global reported natural disasters by type, 1970 to 2019

The annual reported number of natural disasters, categorised by type. This includes both weather and non-weather related disasters.



Source: EMDAT (2020): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium
OurWorldInData.org/natural-disasters • CC BY

Adaptation options

Adaptation key concepts

- Autonomous, incremental, transformational measures
- Ecosystem-based adaptation (EbA)
- Cultural values
- Risk management
- Agroecology and diversification

3 main adaptation measures

Autonomous	Incremental	Transformational
Does not constitute a conscious response to climatic stimuli but is triggered by changes in agroecosystems, markets, or welfare changes	Focuses on improvements to existing resources and management practices	Changes the fundamental attributes of a socio-ecological system

Key climate drivers and risks	Incremental adaptation	Transformational adaptation	Enabling conditions
– Extreme events and short-term climate variability – Stress on water resources, drought stress, dry spells, heat extremes, flooding, shorter rainy seasons, pests	– Change in variety, water management, water harvesting, supplemental irrigation during dry spells – Planting dates, pest control, feed banks – Transhumance, other sources of revenue (e.g., charcoal, wild fruits, wood, temporary work) – Soil management, composting	– Early Warning Systems – Planning for and prediction of seasonal to intra-seasonal climate risks to transition to safer food conditions – Abandonment of monoculture, diversification – Crop and livestock insurance – Alternate cropping, intercropping – Erosion control	– Establishment of climate services – Integrated water management policies, integrated land and water governance – Seed banks, seed sovereignty and seed distribution policies – Capacity building and extension programmes
– Warming trend, drying trend – Reduced crop productivity due to persistent heat, long drought cycles, deforestation and land degradation with strong adverse effects on food production and nutrition quality, increased pest and disease damage	– Strategies to reduce effects of recurring food challenges – Sustainable intensification, agroforestry, conservation agriculture, SLM – Adoption of existing drought-tolerant crop and livestock species – Counter season crop production – Livestock fattening – New ecosystem-based adaptation (e.g., bee keeping, woodlots) – Farmers management of natural resources – Labour redistribution (e.g., mining, development projects, urban migration) – Adjustments to markets and trade pathways already in place	– Climate services for new agricultural programmes (e.g., sustainable irrigation districts) – New technology (e.g., new farming systems, new crops and livestock breeds) – Switches between cropping and transhumant livelihoods, replacement of pasture or forest to irrigated/rainfed crops – Shifting to small ruminants or drought resistant livestock or fish farming – Food storage infrastructures, food transformation – Changes in cropping area, land rehabilitation (enclosures, afforestation) perennial farming – New markets and trade pathways	– Climate information in local development policies – Stallholders' access to credit and production resources – National food security programme based on increased productivity, diversification, transformation and trade – Strengthening (budget, capacities, expertise) of local and national institutions to support agriculture and livestock breeding – Devolution to local communities, women's empowerment, market opportunities – Incentives for establishing new markets and trade pathways

Ecosystem-based adaptation

https://www.iucn.org/resources/issues-briefs/ecosystem-based-adaptation

Supply and Demand side of adaptation

Supply-side adaptation

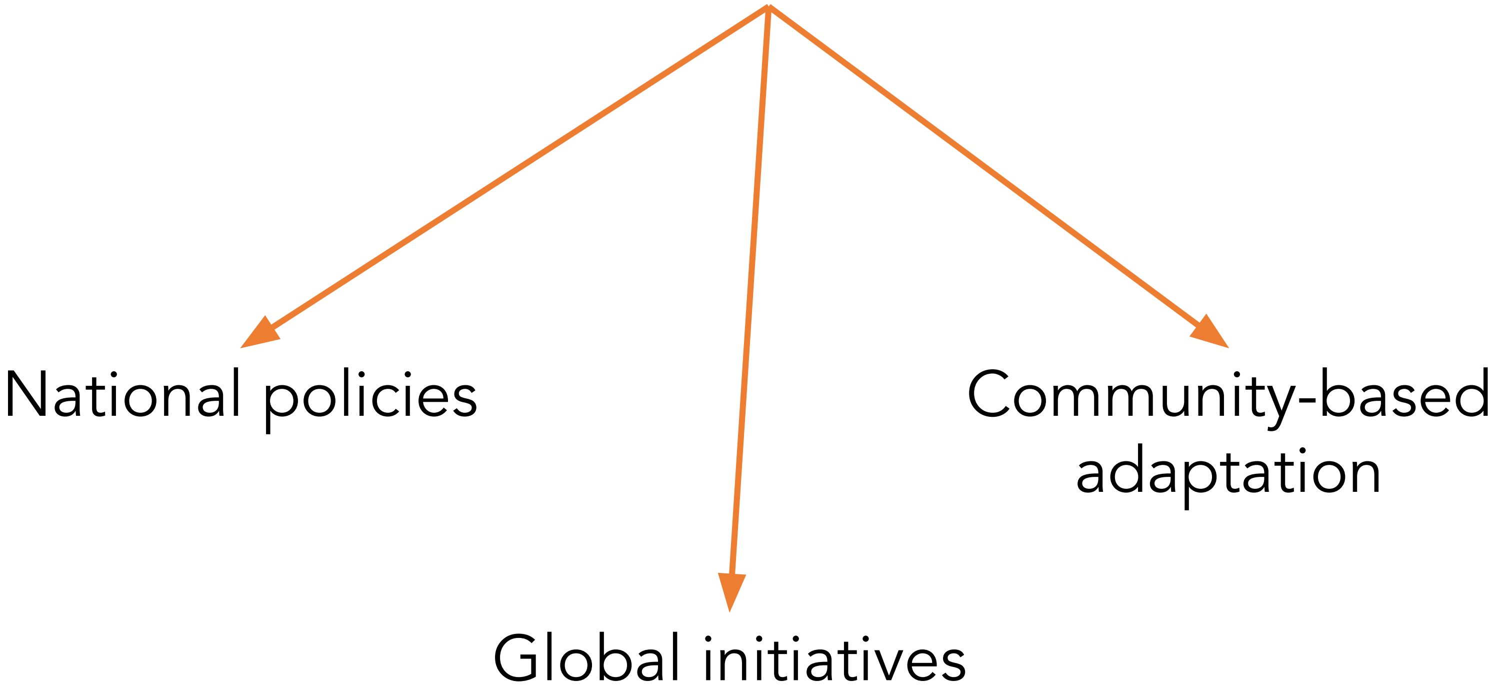
On crop production	Improved cropland management; increased food productivity; prevention and reversal of soil erosion; soil management (change sowing date, crop type); biophysical adaptation(more drought, flood and heat-resistant crop varieties); water management (improve drainage system)
On livestock production	Intensification, integration with crops; shifting from grazing to browsing species; multispecies herds; nutrient management; water management; pasture management; farm diversification or cooling systems
On transportation and storage	Strengthening infrastructure and logistics; improving food and nutrition security; using modern technologies in storage;
On trade and processing	Developing food trade; supporting food markets; using modern technologies in packaging;

Demand-side adaptation

- Adoption of diets low in animal-sourced products
- Reduction in food loss
- Effective food waste management

Institutional measures

Institutional measures



United Nations
Climate Change

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

GLOBAL
COMMISSION ON
ADAPTATION

GACSA
GLOBAL ALLIANCE FOR
CLIMATE-SMART AGRICULTURE

F A O
FIAT PANIS

WORLD
RESOURCES
INSTITUTE

Tools for adaptation

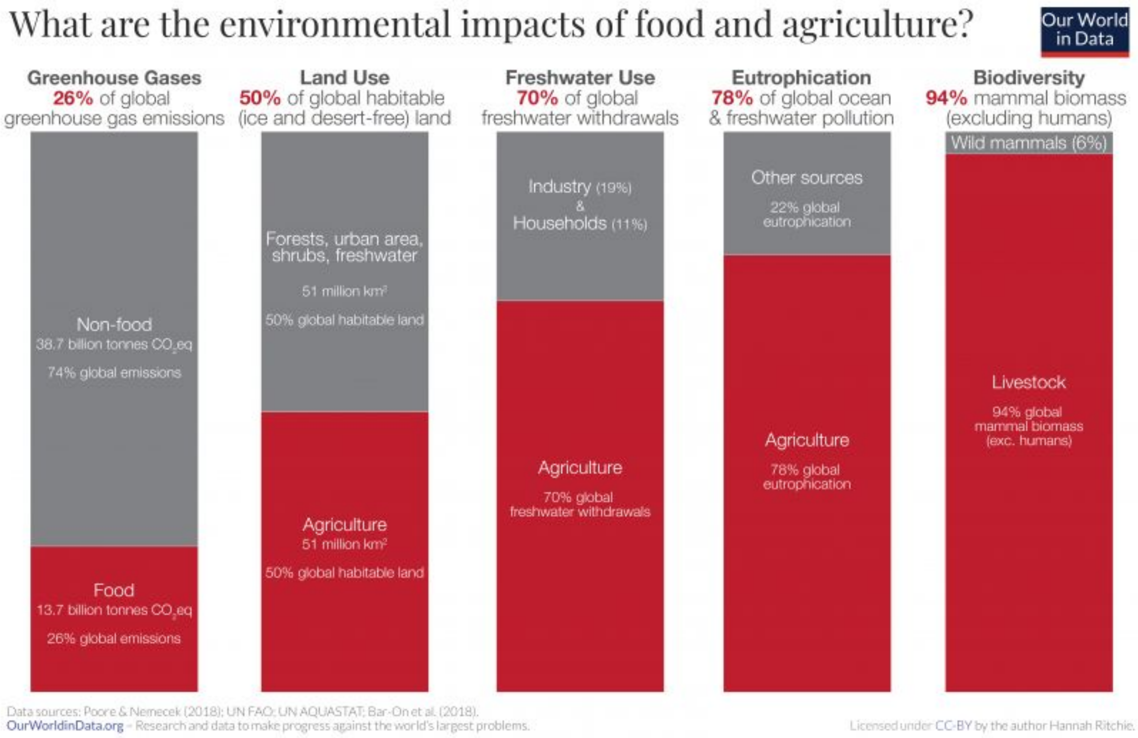
Early warning systems

Financial resources

Impacts of Our Food Systems on the Climate

GHG Emissions from food systems - Overview

- Food systems emissions - CO2 and non-CO2 gases
  - CH4 – methane
  - N2O – nitrous oxide
- Sources:
  - Crops & livestock
  - Land use & land-use change
  - Upstream & downstream processes



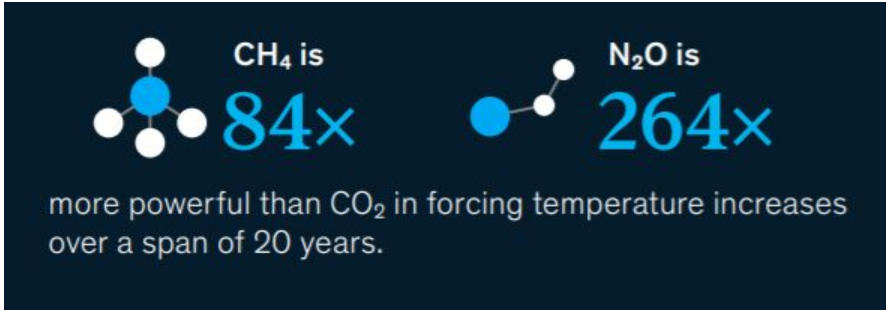
Agriculture & land use

Table 5.4 | GHG emissions ($GtCO_2$-eq yr^{-1}) from the food system and their contribution (%) to total anthropogenic emissions. Mean of 2007–2016 period.

Food system component	Emissions (Gt CO_2eq yr^{-1})	Share in mean total emissions (%)
Agriculture	6.2 ± 1.4[a,b]	9–14%
Land use	4.9 ± 2.5[a]	5–14%
Beyond farm gate	2.6[c] – 5.2[d]	5–10%[e]
Food system (total)	10.8 – 19.1	21–37%

Within the farm gate

- Agriculture & land use
    - 50% total CH4 emitted by all sectors
    - 75% of total N2O emitted by all sectors
    - 10% of total CO2 emitted by all sectors



Beyond the farm gate

- Upstream & downstream processes
- Hard to estimate

Emissions From Croplands and Soils

- Estimates vary - 2–3 $GtCO_2$-eq per year, 3.6 ± 1.2 $GtCO_2$-eq per year
  - Peatland degradation
  - N_2O emissions from synthetic fertilizers
  - Methane emissions from paddy rice fields

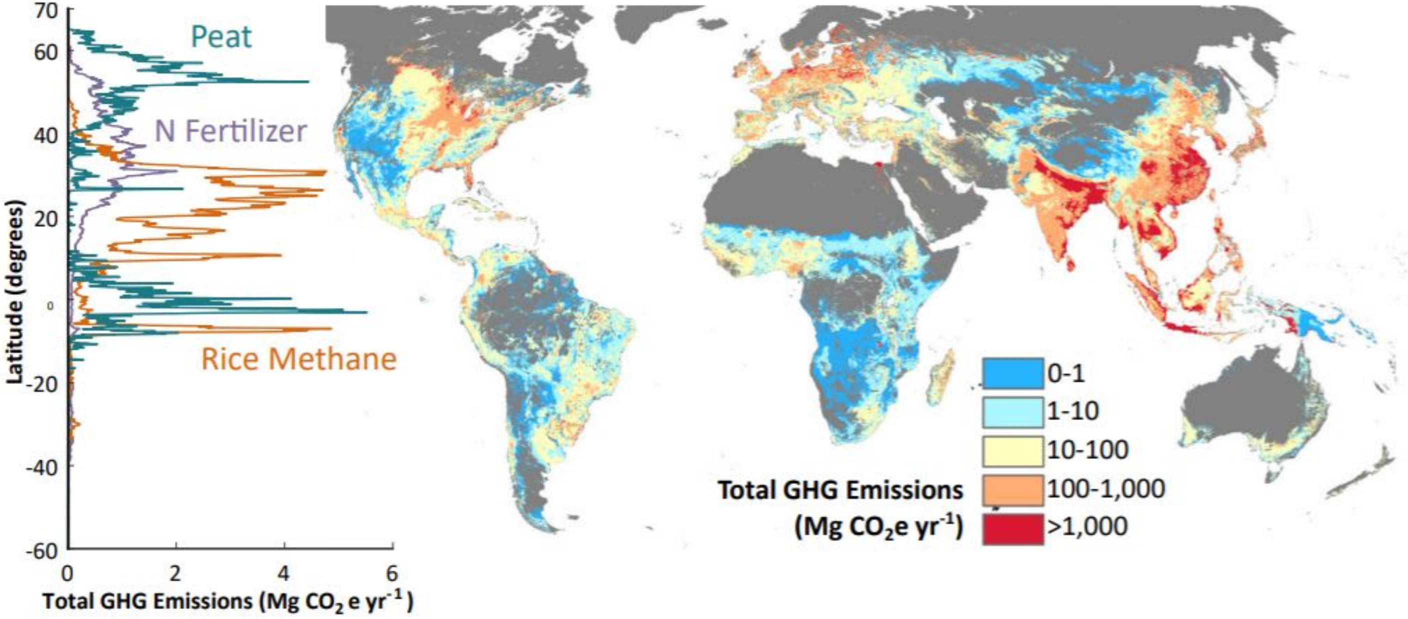


Figure 5.9 | Cropland GHGs consist of CH_4 from rice cultivation, CO_2, N_2O, and CH_4 from peatland draining, and N_2O from N fertiliser application. Total emissions from each grid cell are concentrated in Asia, and are distinct from patterns of production intensity (Carlson et al. 2017).

Emissions From Livestock

- Emissions estimates vary - 2.0–4.1 GtCO2-eq per year
  - Add land-use change, energy use & transportation processes 5.3 ±1.6 GtCO2-eq per year
- Red meat most inefficient in terms of emissions/kg of protein
- Benefits from increased efficiency may drive demand

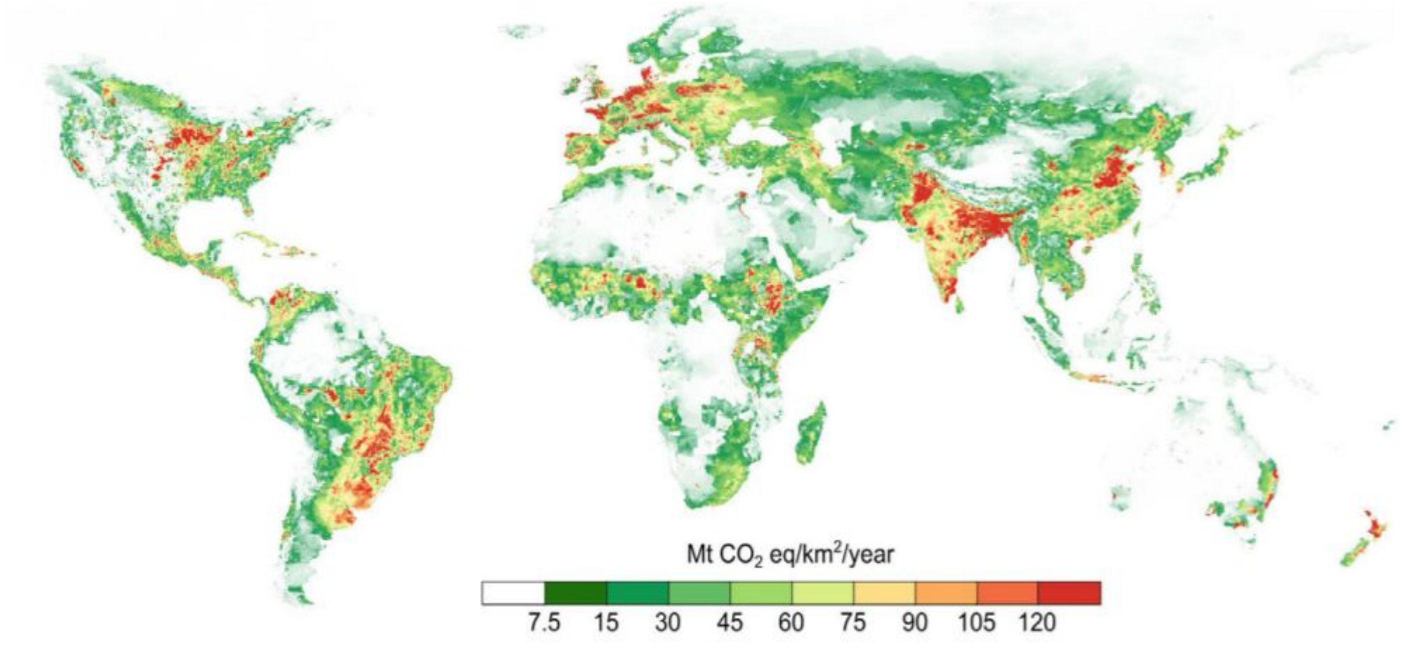
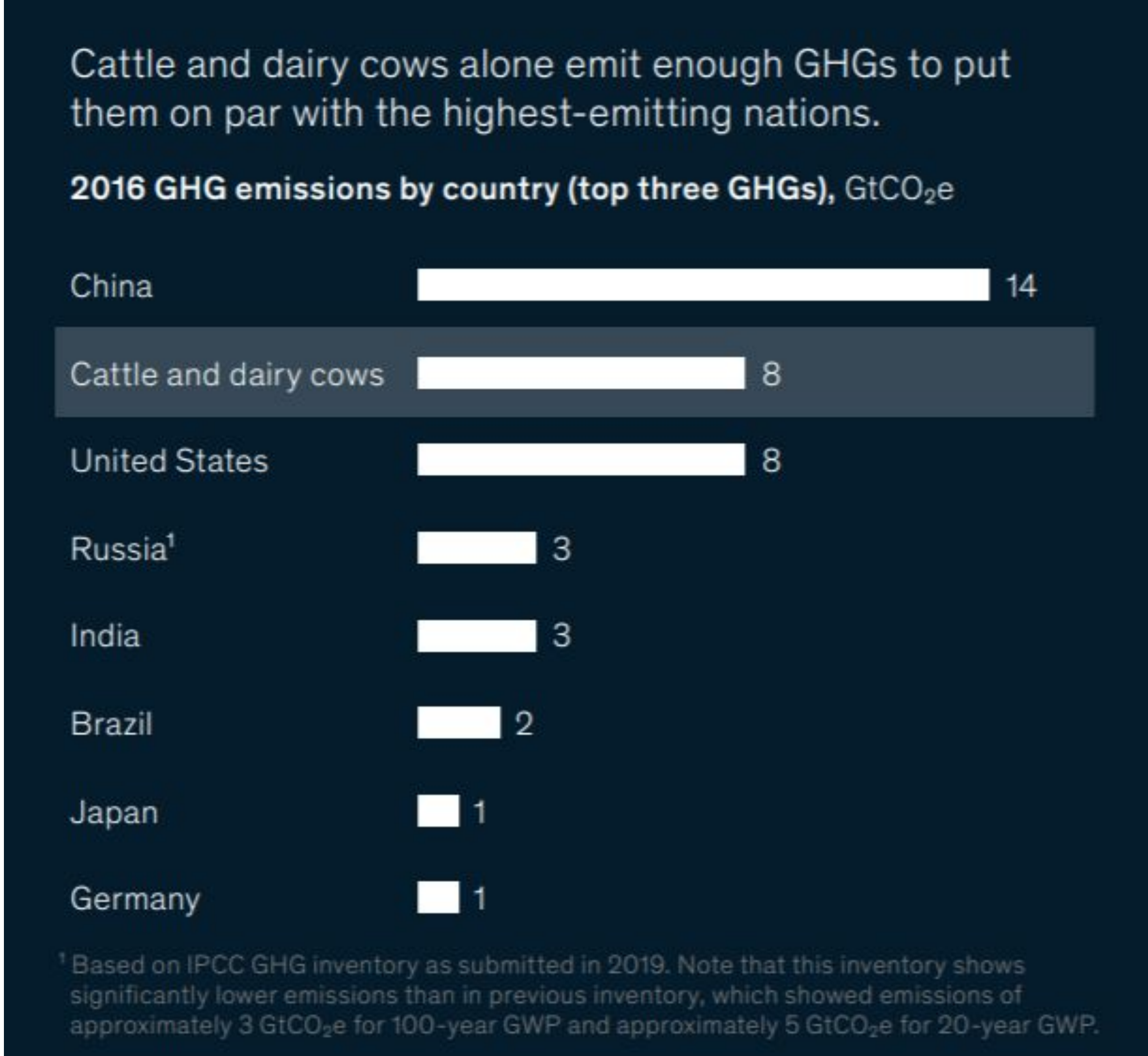


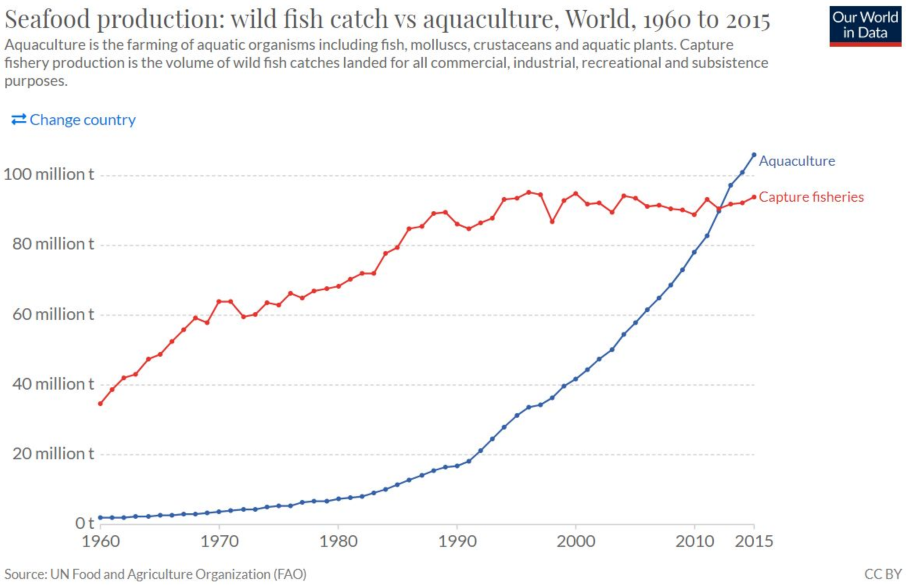
Figure 5.10 | Global GHG emissions from livestock for 1995–2005 (adapted from Herrero et al. 2016a).

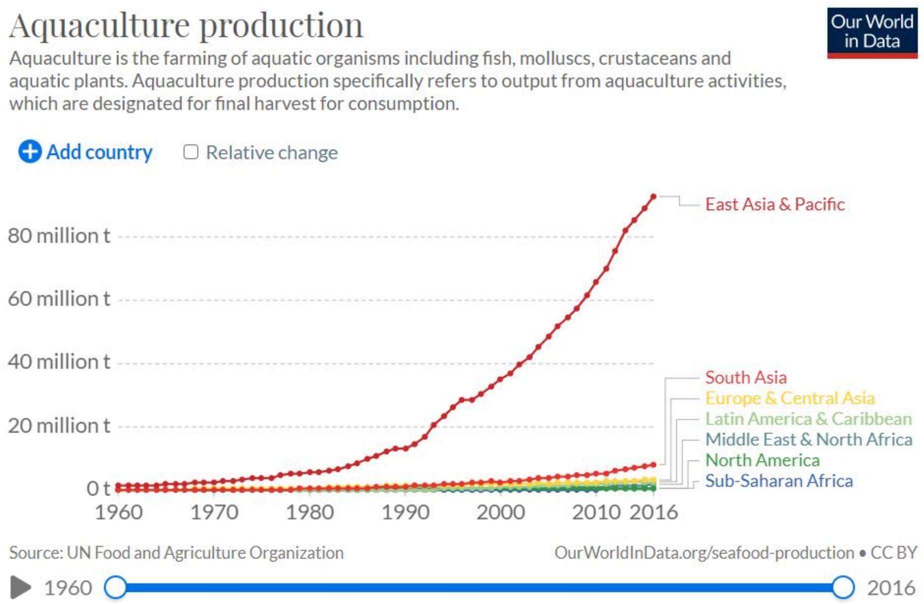
Emissions From Livestock



Emissions From Aquaculture

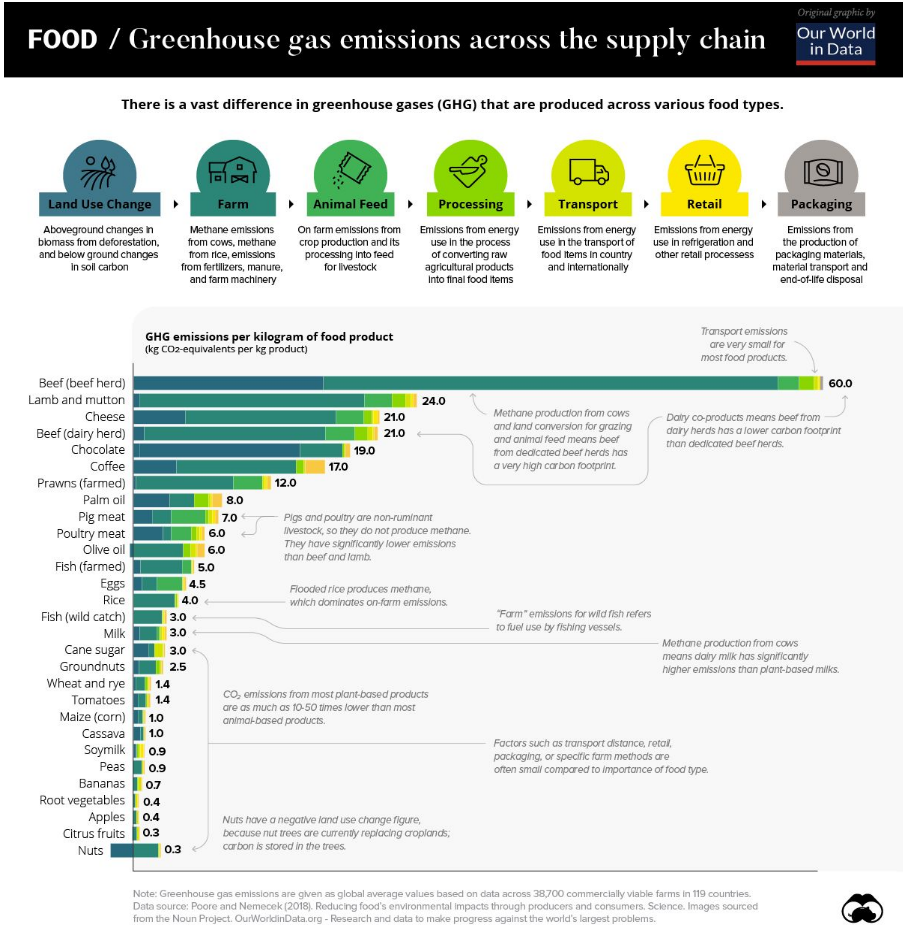
- 10% of total agriculture emissions, ~0.58 GtCO2-eq per year
- 2/3 of emissions are non-CO2
    - Remaining emissions - fuel use in fishing vessels
    - Eutrophication





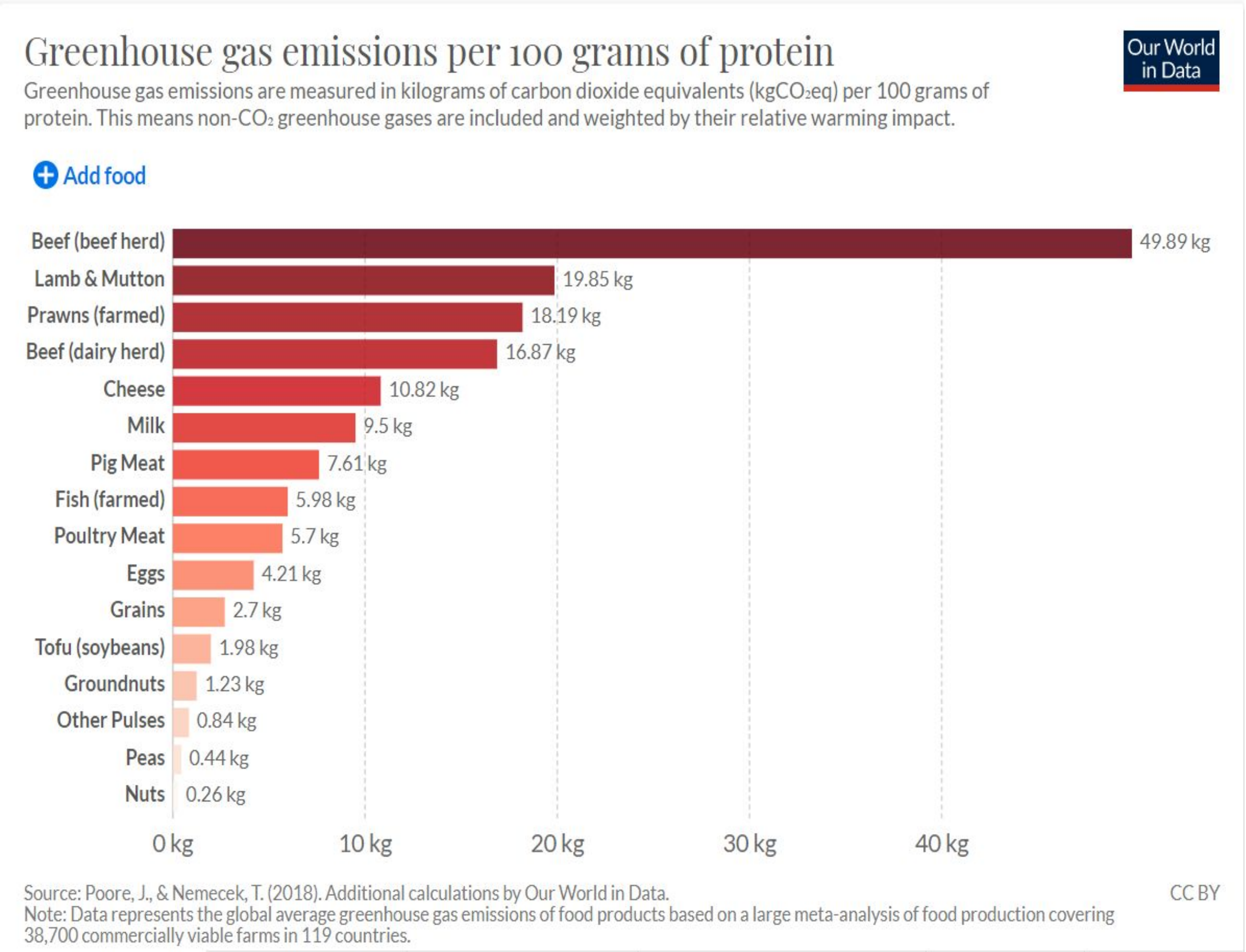
Emission From Inputs, Processing, Storage, and Transport

- Manufacturing - fertilizers, pesticides, feed
- Processing, storage, refrigeration, retail,
  waste disposal, food service, and transport.
- ~10% of anthropogenic emissions
- Globalization of agriculture



Emissions Associated with Diet

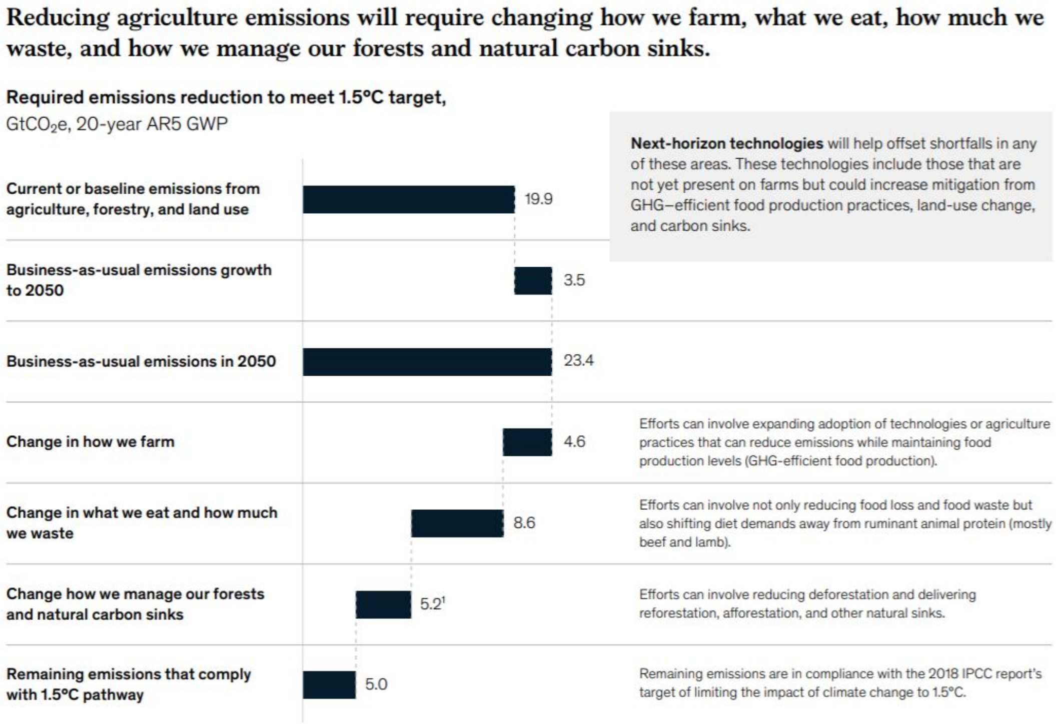
- Higher consumption of animal-based foods = greater environmental impacts
- Ruminant meat has greatest emissions & land use
- Plant-based diets



Mitigation, Challenges, & Opportunities

Mitigation Options, Challenges, and Opportunities

- Emissions expected to increase 30-40% by 2050 (8–9 Gt CO2-eq/year)
- Two sides to consider:
  - Supply side
  - Demand side



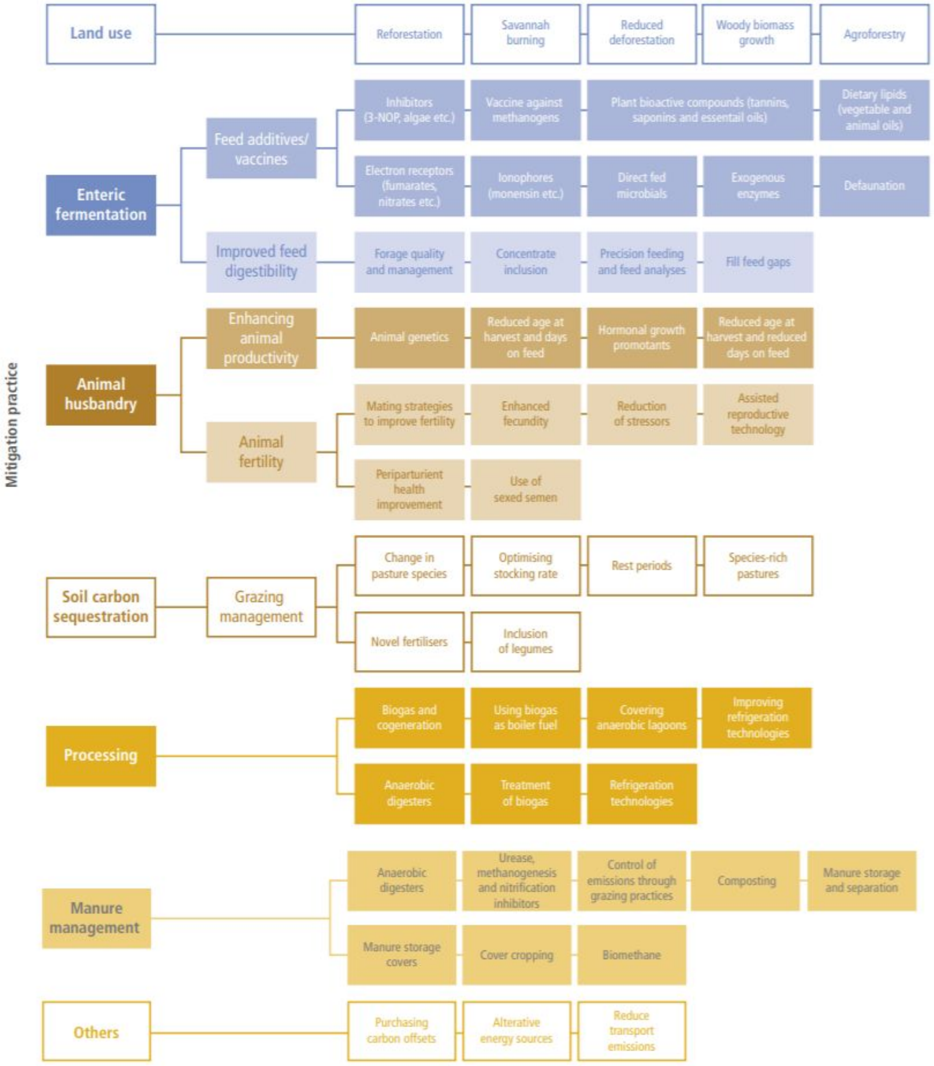
Supply Side Mitigation: Croplands and Soils

- Cropland management, restoring organic soils, grazing land management, etc.
- Mitigation potential - 1.6–4.6 $GtCO_2$-eq/year by 2030
- Key mitigation pathways must:
    - Reduce nitrous oxide emissions
    - Reduce methane emissions
    - Improving carbon sequestration

Livestock Systems

- Mitigation potential of 0.2-2.4 $GtCO_2$-eq per year (excluding land-use practices)
- Mitigations in this sector must:
    - Reduce enteric methane
    - Reduce nitrous oxide through manure management
    - Sequester carbon in pastures
    - Improve animal husbandry & management practices

- Different production systems require different strategies



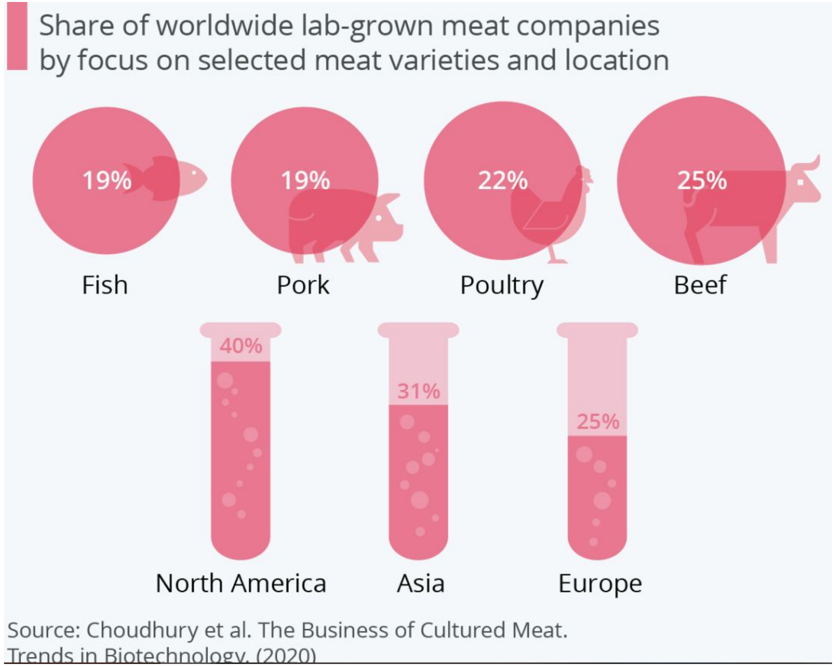
Technical supply-side mitigation practices in the livestock sector

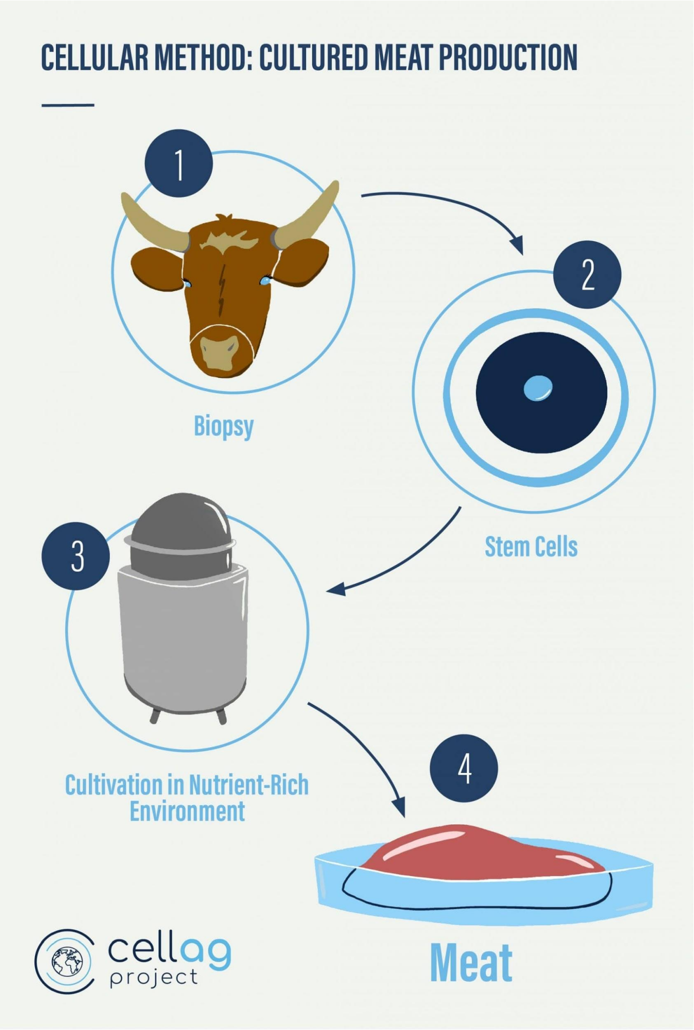
Mitigation in Aquaculture

- Mitigation options may:
  - Reduce emissions in production of feed material
  - Replace fish-based feed ingredients
  - Improve feed conversion rates
  - Move to renewable energies
  - Improve fish health
- Avoiding deforestation of mangroves

Cellular Agriculture

- Lab-grown meat / Cultured meat
- ~60% reduction in energy use
- 1% of land use of traditional beef





Demand Side Mitigation: Diet

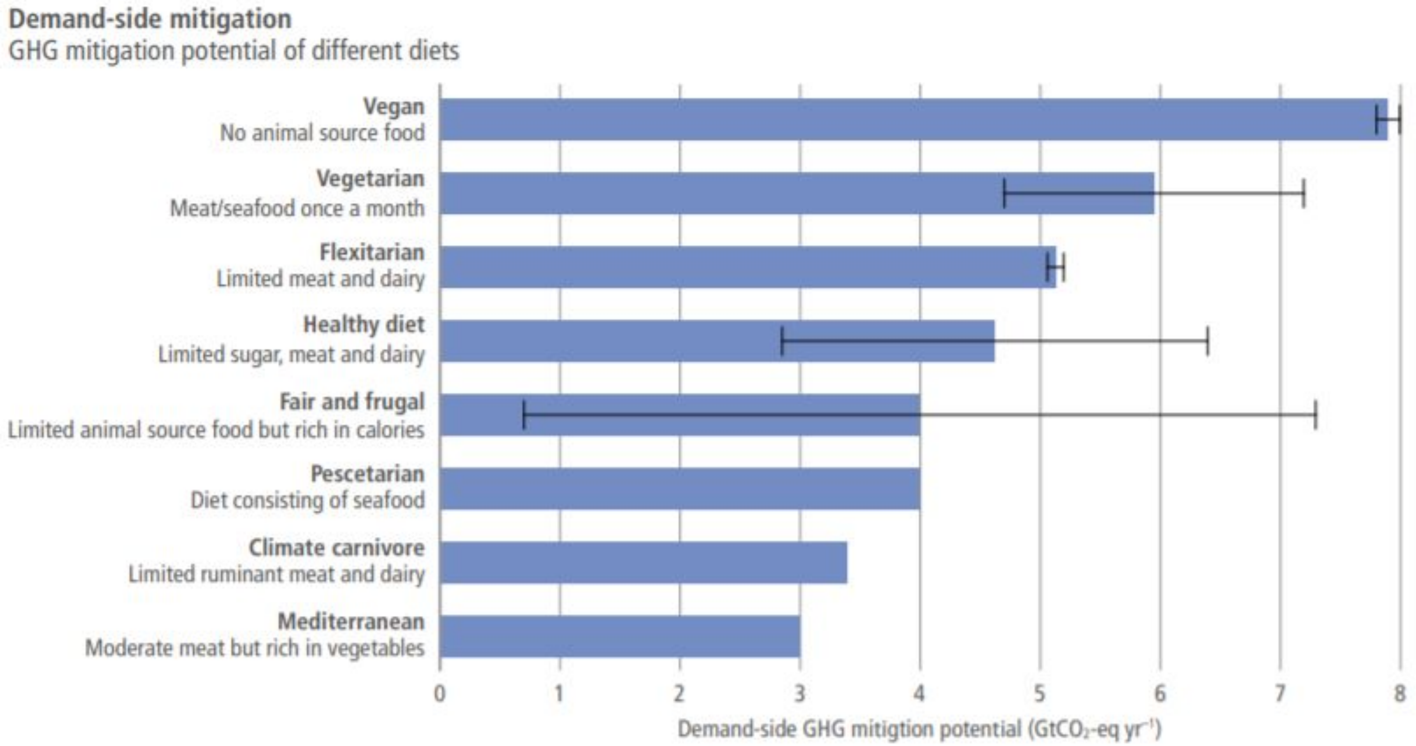
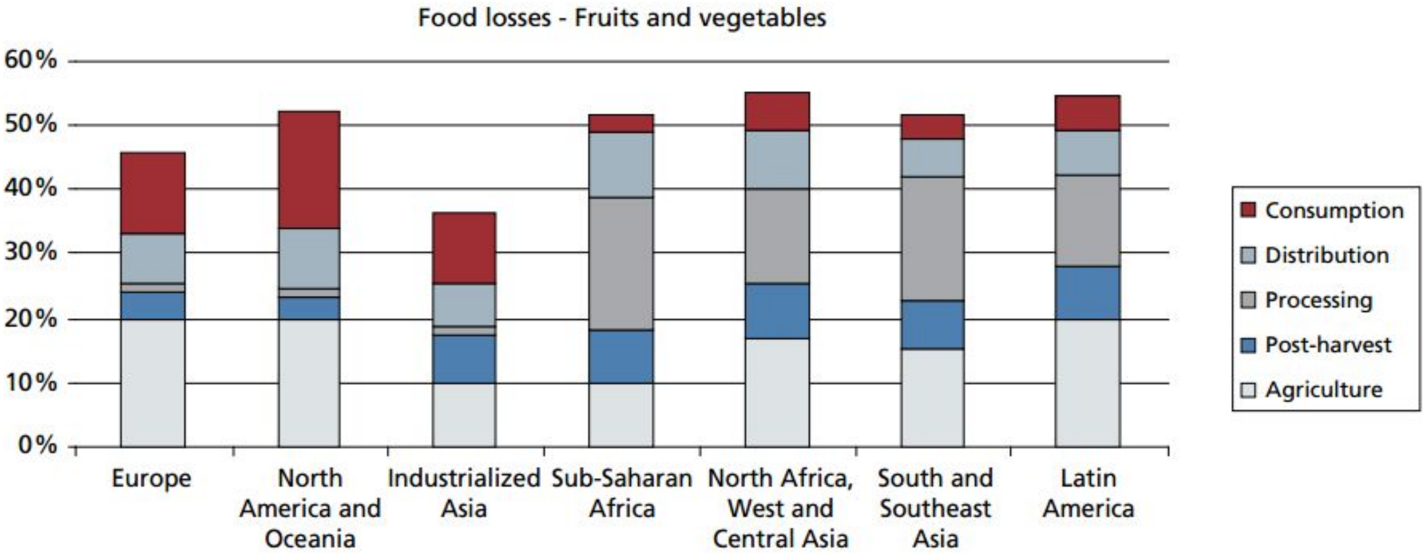


Figure 5.12 | Technical mitigation potential of changing diets by 2050 according to a range of scenarios examined in the literature. Estimates indicate technical potential only and include additional effects of carbon sequestration from land-sparing. Data without error bars are from one study only.

Food Loss and Food Waste

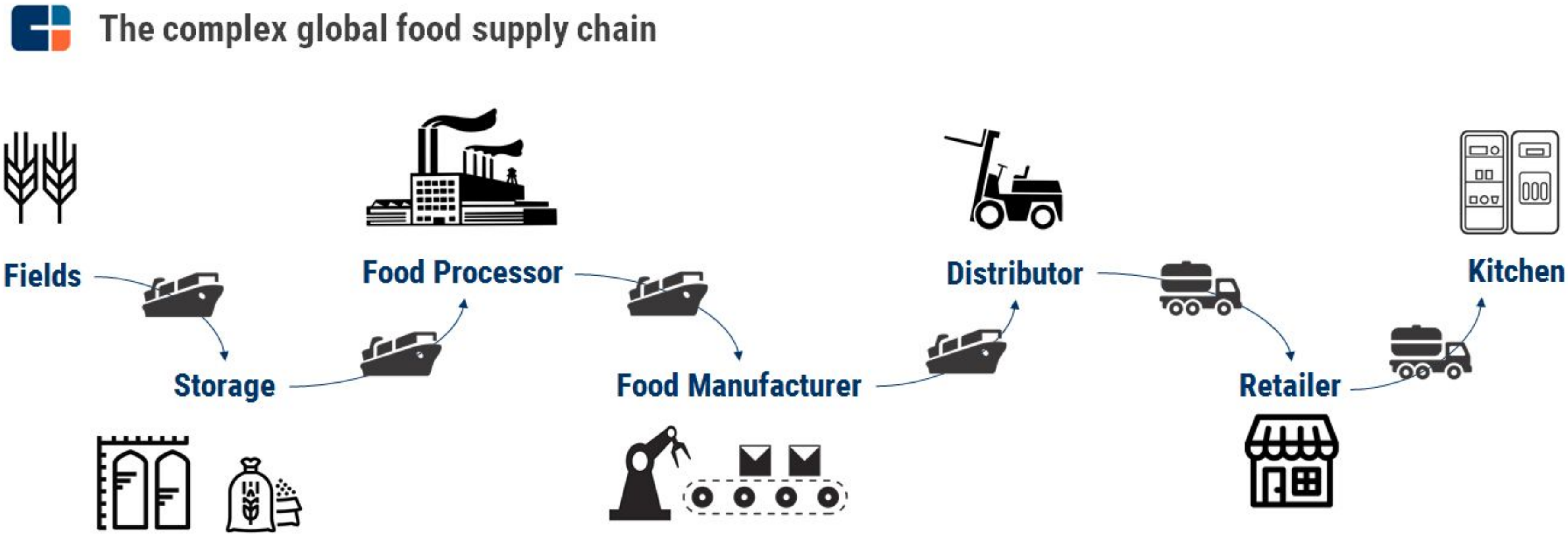
- Food loss & waste = 25-30% of all food produced
- 540 metric tons in 1960, 1630 metric tons in 2011
- By 2050, projected emissions of 1.9-2.5 gigatons of CO_2-eq/year

Part of the initial production lost or wasted at different stages of the FSC for fruits and vegetables in different regions



Shortening Supply Chains

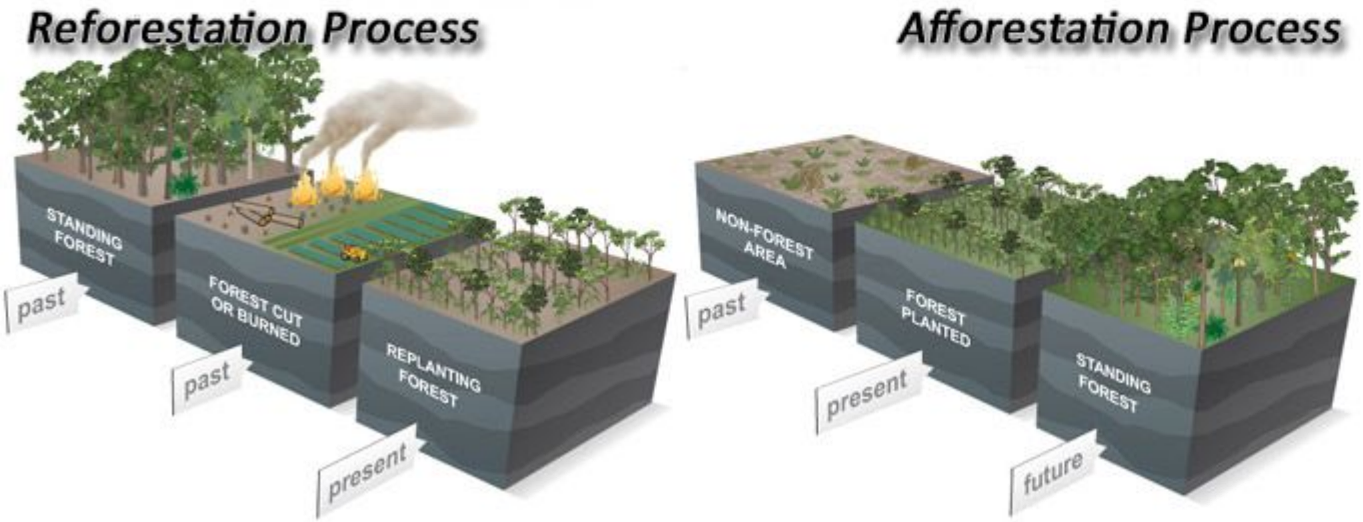
- Eat local--but not always
- Not all forms of transportation are equal



Land-based CDRs (Carbon Dioxide Removals):

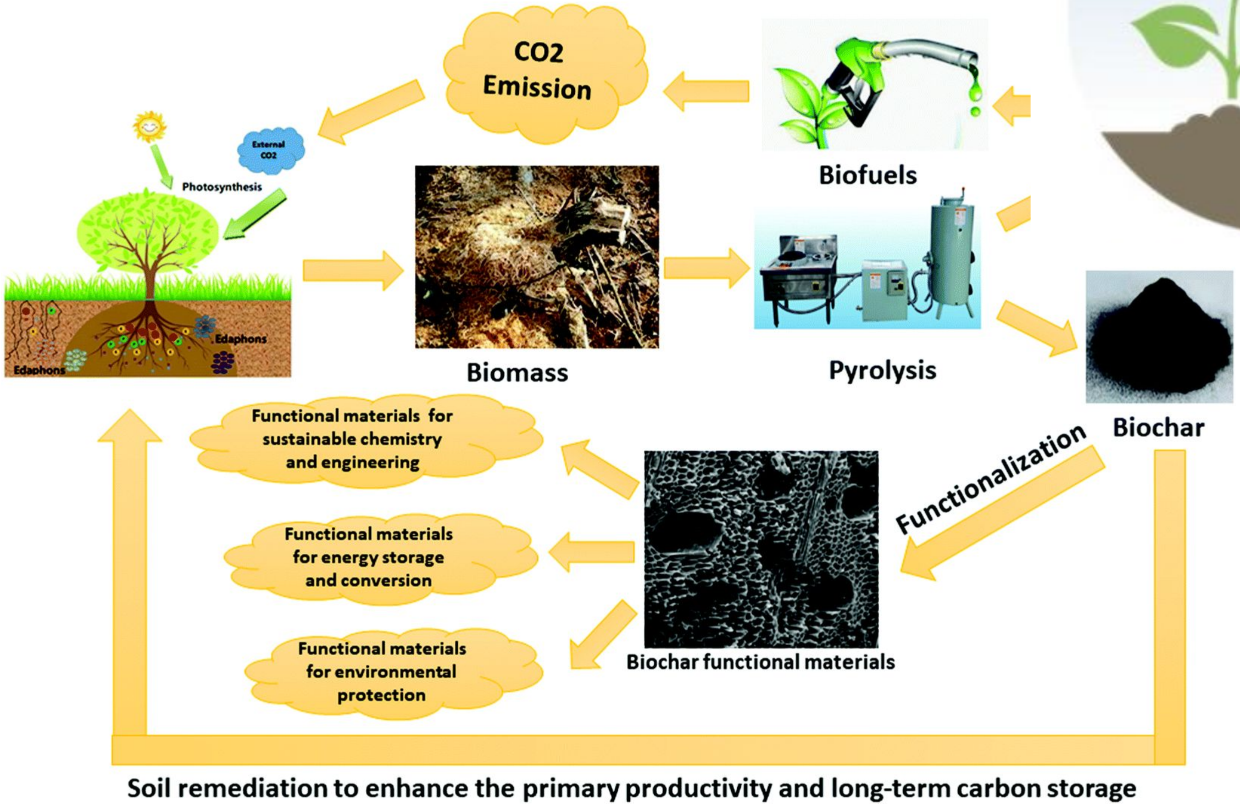
1. Afforestation and reforestation (AR)

Afforestation and Reforetation
Tree growth takes up CO_2 from the atmosphere.



http://geoengineeringinquiries.blogspot.com/2016/01/afforestation-and-deforestation.html

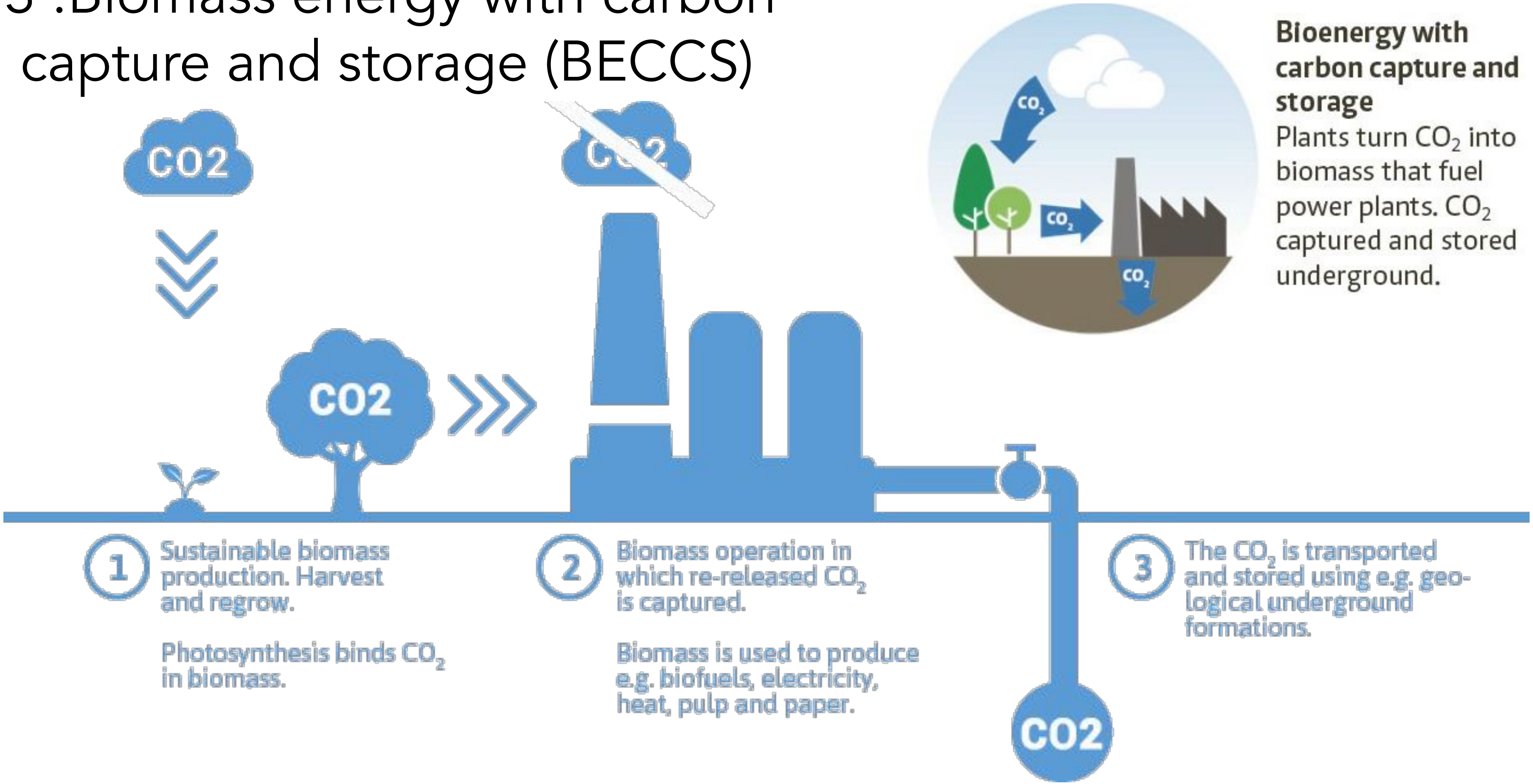
2. Biochar (BC) production



Biochar
Partly burnt biomass is added to soils absorbing additional CO_2.

https://pubs.rsc.org/en/content/articlelanding/2019/ee/c9ee00206e/unauth#!divAbstract

3 .Biomass energy with carbon capture and storage (BECCS)



https://350bayarea.org/really-tackling-climate-change/beccs

Challenges with CDRs

- investments and changes in land use
- previous land-use and soil management practices
- type of biomass, crop productivity, and emissions offset in the energy system
- land-use change interactions
- food prices and reduced food security

The influence of climate change on food prices & particular countries

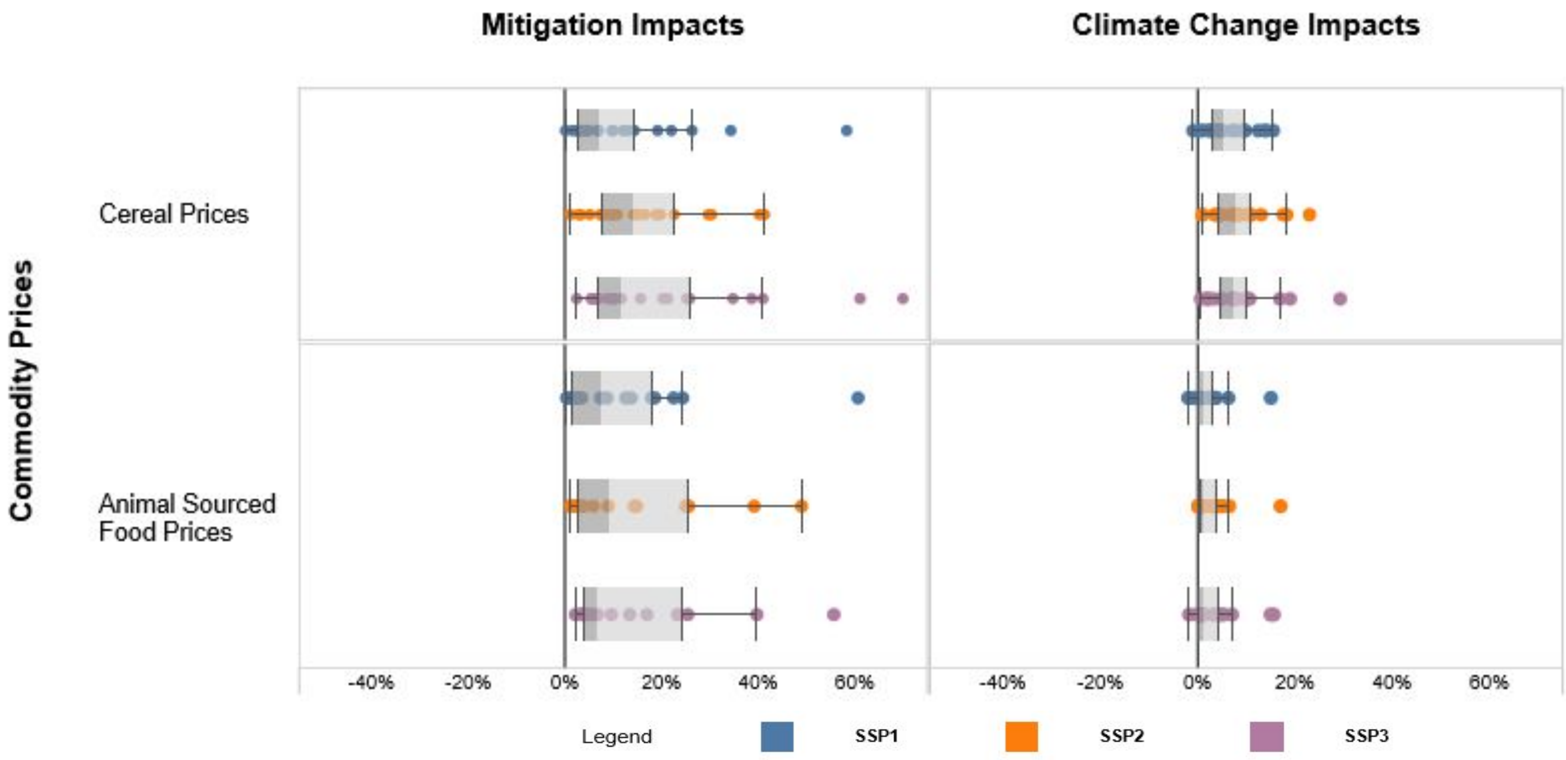
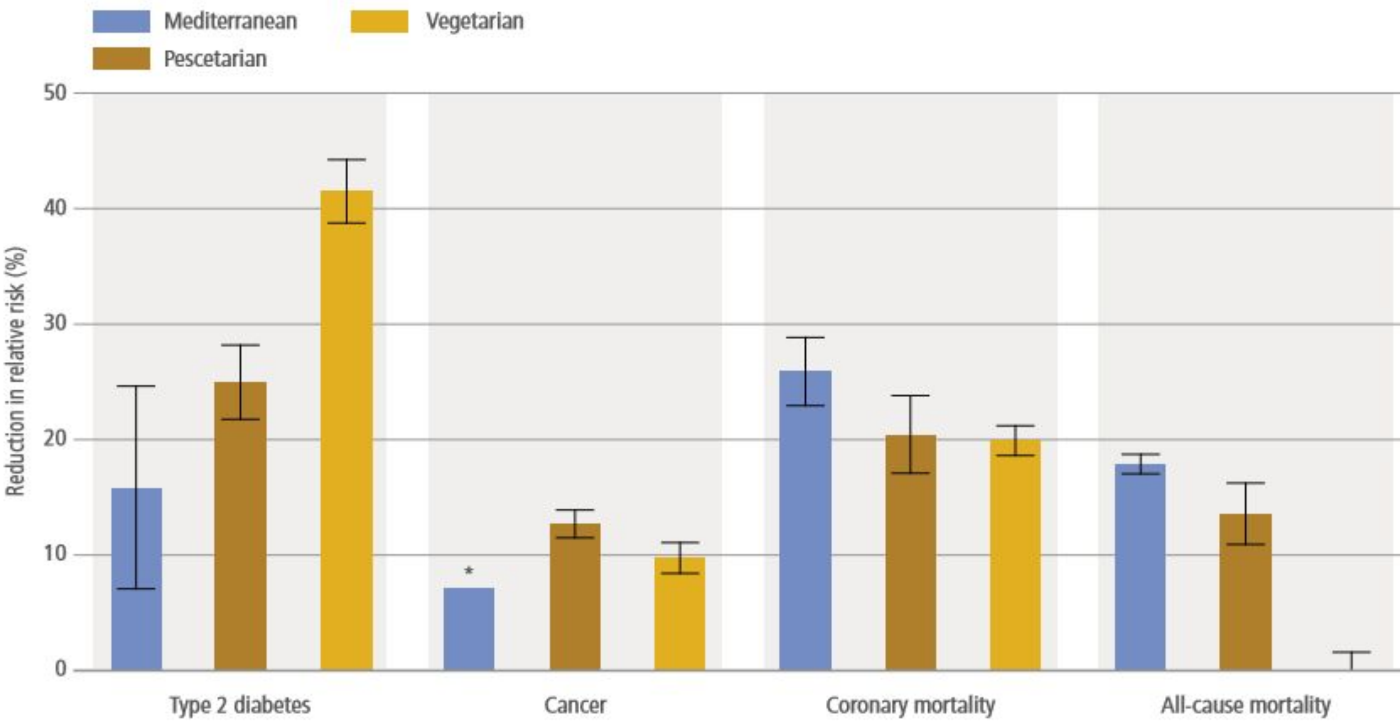


Figure 5.14 | Regional impacts of climate change and mitigation on food price (top), population at risk of hunger or undernourishment (middle), GHG emissions (bottom) in 2050 under different socio-economic scenarios (SSP1, SSP2 and SSP3) based on AgMIP Global Economic Model analysis. Values indicate changes from no climate change and no climate change mitigation scenario. MAgPIE, a global land-use allocation model, is excluded due to inelastic food demand. The value of India includes that of Other Asia in MAGNET, a global general equilibrium model (Hasegawa et al. 2018).

Environmental and health effects of adopting healthy and sustainable diets

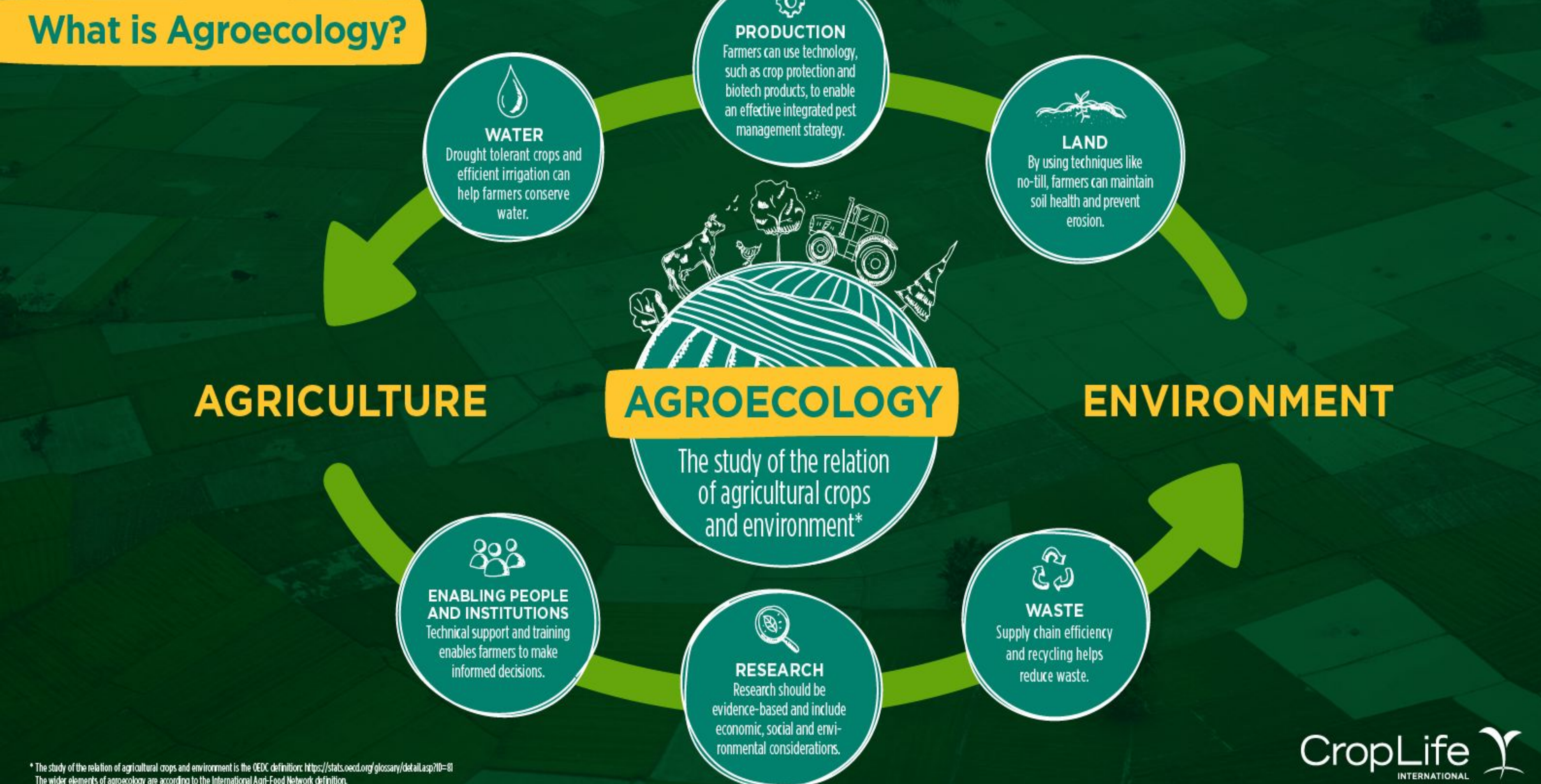
Can dietary shifts provide
significant benefits?

Are 'low GHG emission diets'
healthy?



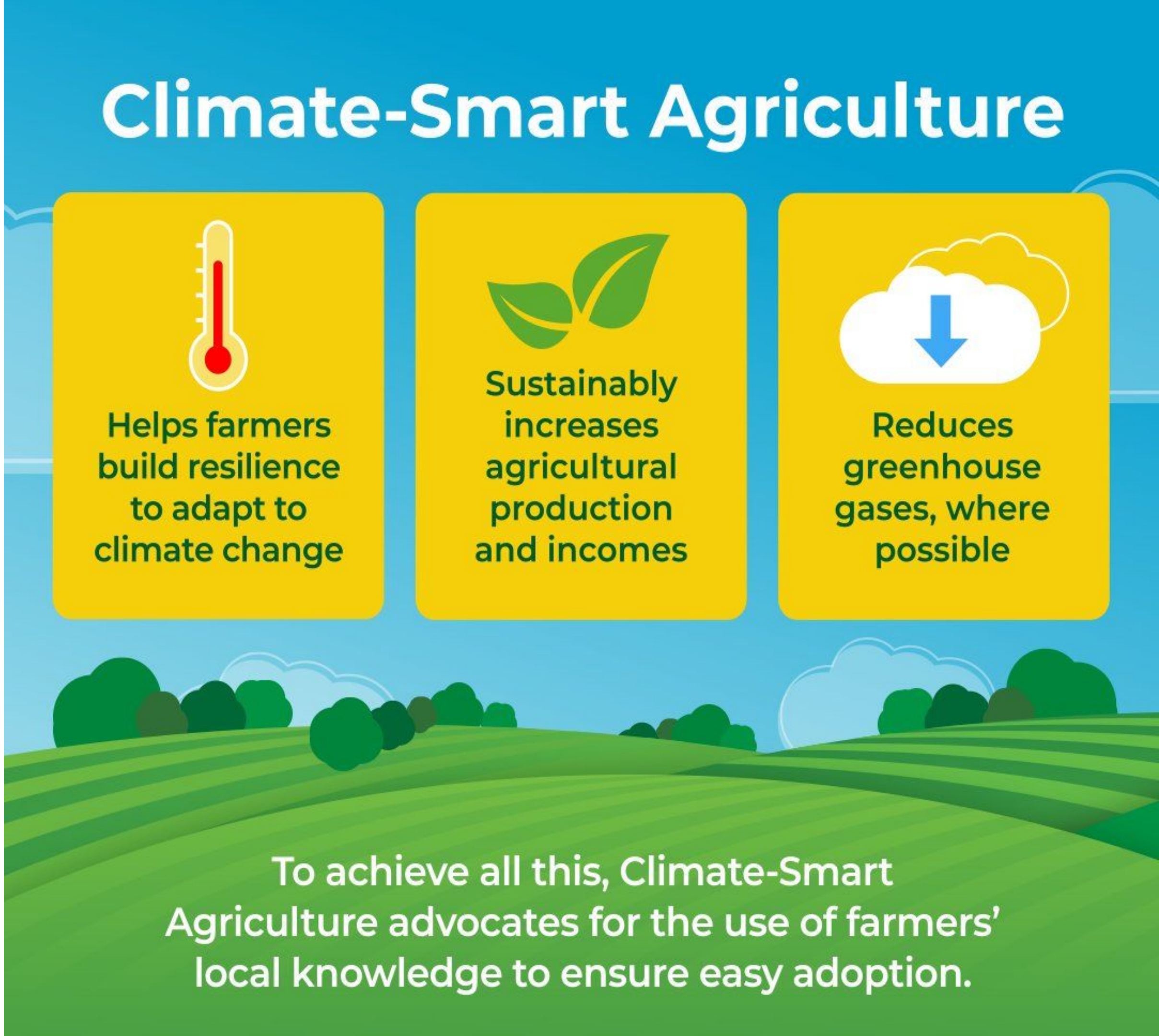
Diet and health effects of different consumption scenarios (Tilman and Clark 2014) (*reflects data from a single study, hence no error bars

Sustainable integrated agricultural systems

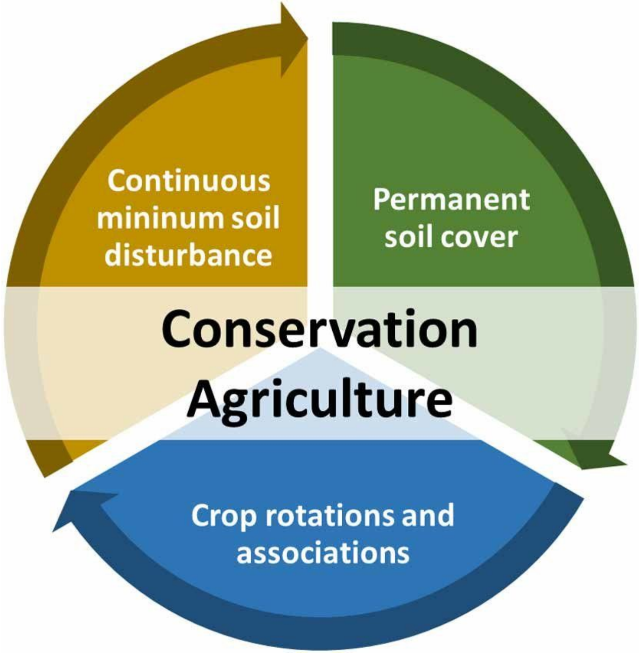


https://farmgro.africa/youth-and-agroecology-national-summit-2020

Climate-smart agriculture



Conservation agriculture



https://www.researchgate.net/figure/Basic-principles-of-Conservation-Agriculture_fig1_338747348

Sustainable intensification

https://www.nature.com/collections/jieihecica#:~:text=Feeding%20a%20growing%20and%20increasingly,seeks%20to%20balance%20these%20priorities.

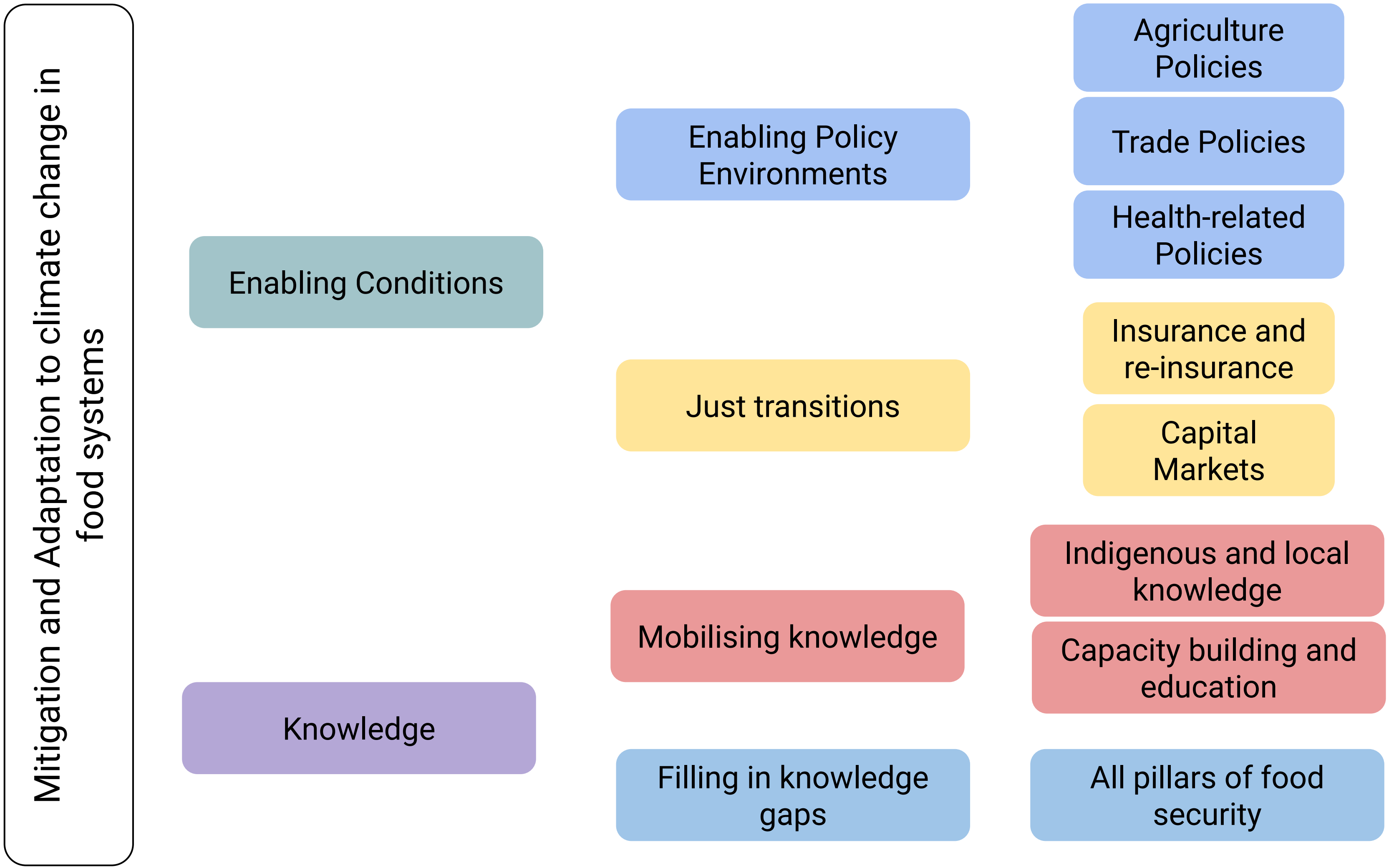
Role of urban agriculture

In 2010, around 14% of the global population was nourished by food grown in urban and peri-urban areas

https://www.agritecture.com/blog/2020/1/27/the-worlds-first-commercial-scale-indoor-tomato-farm-to-open-in-uae

https://www.prc-magazine.com/jll-launch-urban-farm-atop-bank-of-america-tower/

Enabling conditions & Future Challenges


Mitigation and Adaptation to climate change in food systems
Enabling Conditions
Knowledge
Enabling Policy Environments
Just transitions
Mobilising knowledge
Filling in knowledge gaps
Agriculture Policies
Trade Policies
Health-related Policies
Insurance and re-insurance
Capital Markets
Indigenous and local knowledge
Capacity building and education
All pillars of food security

Future challenges to food security

1. Food Price Spikes

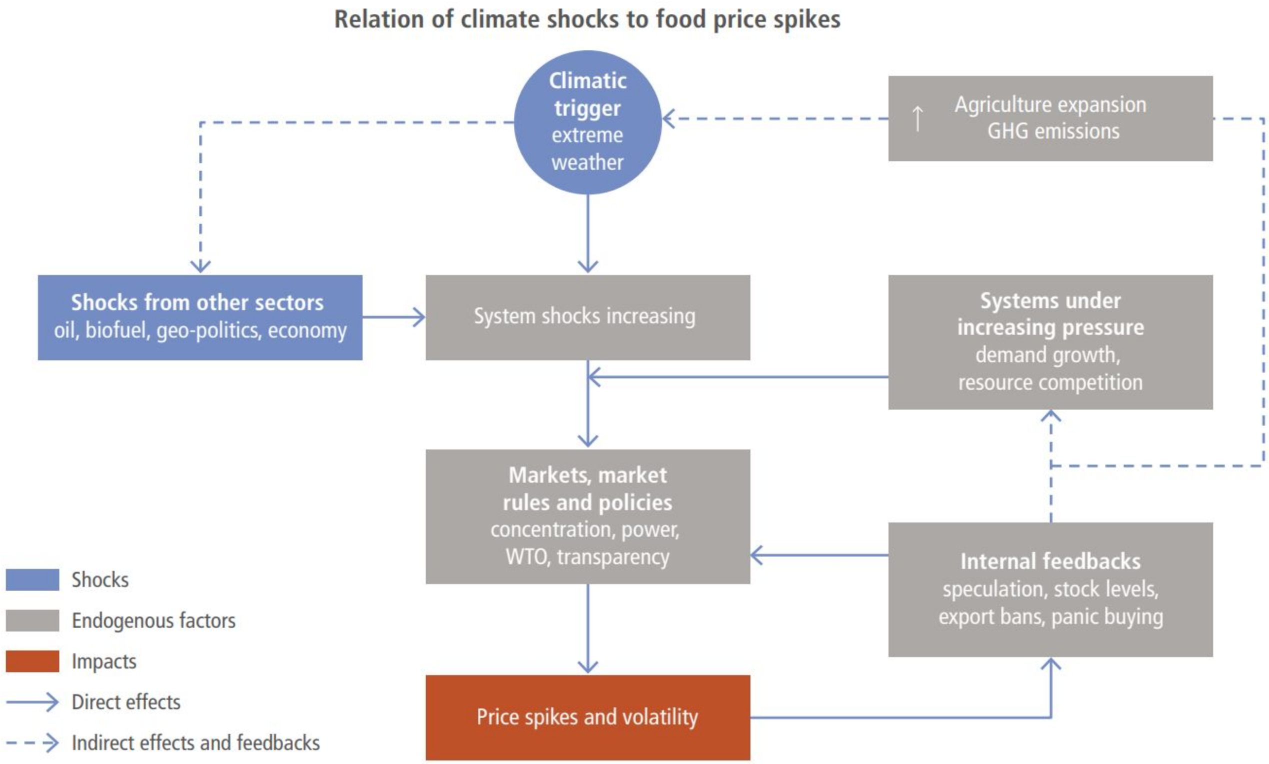
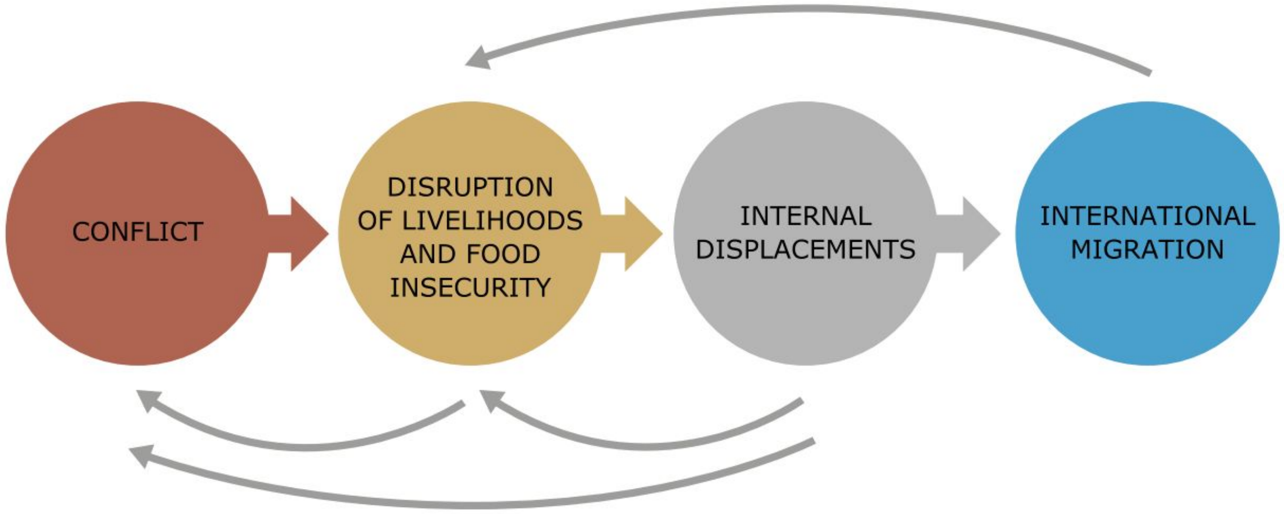


Figure 5.17 | Underlying processes that affect the development of a food price spike in agricultural commodity markets (Challinor et al. 2018).

Future challenges to food security

2. Migration and Conflict

Figure 4.17: The vicious cycle of conflict, poverty, food insecurity and migration



Conclusion