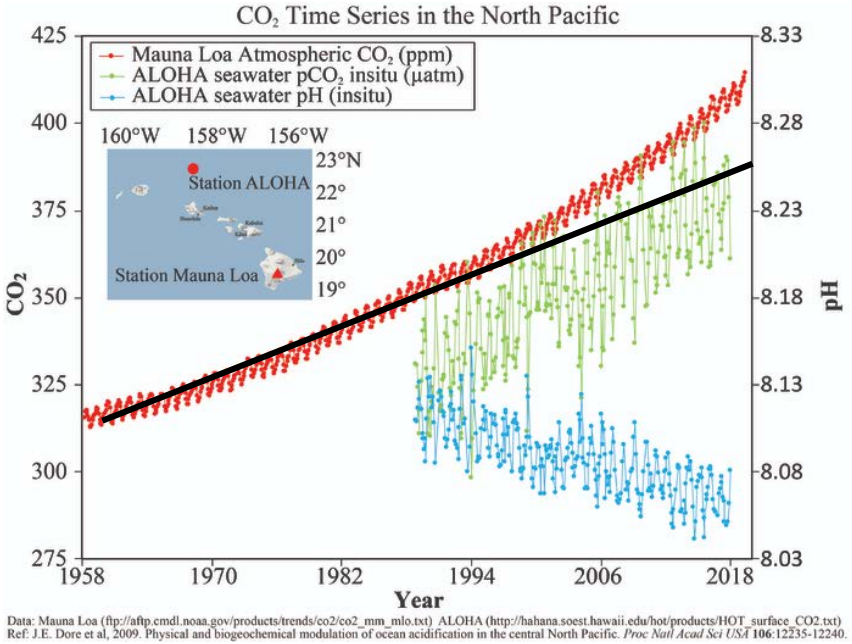
Climate change, diets and land



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Food security: what does it mean?

Definitions

Food security

A situation that exists 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*.

- Food security is about sustainably supplying nutritious diets, not simply growing more calories

Food system

All the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the output of these activities, including socio-economic and environmental outcomes

- Food security arises as an outcome from the food system, it is not simply mapped onto agriculture
- The "food system" connects supply and demand. Reduction in impacts can arise from changing farming directly, or from changing the demand for the products that have an impact

Climate change: what does it mean?

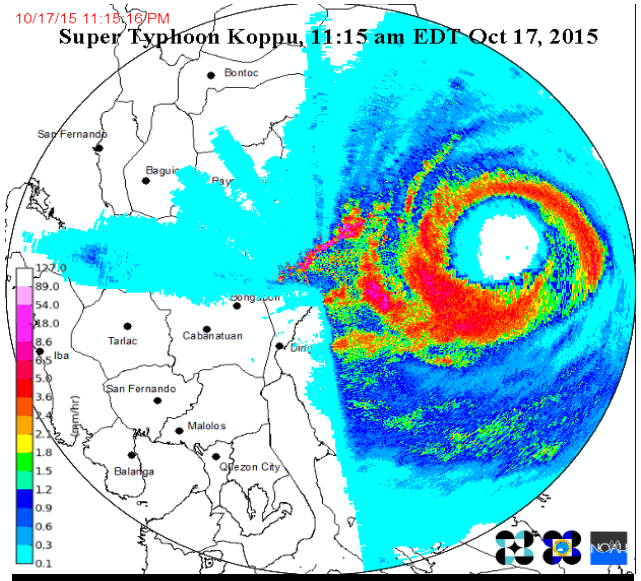
Food systems are affected by climate change in many ways :

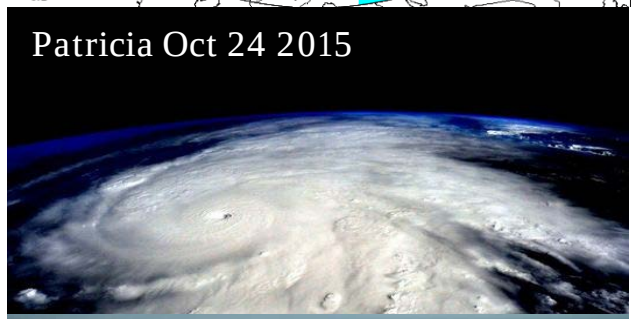
- Through changing the climate:
  - Where can crops (and livestock) grow?
  - Where can pests and diseases live?
  - Creating mismatches between growth periods of plants and their pollinators
  - Changing the quality of crops (e.g. sugar levels) by changing the timing of the growing season
  - Affecting nutritional quality and spoilage of stored food (e.g. changing rainfall, changing humidity, changing aflatoxin contamination)

- Through changing the weather, particularly its variability, extremes and predictability:
  - Drought and heat affects plant and livestock yields
  - Extreme precipitation can destroy crops, and prevent access to land
  - Unseasonable weather can disrupt development e.g. strong winds removing flowers from fruit trees
  - Disrupting supply chains by affecting infrastructure and thus availability

- Through changing basic biology:
  - Plants use photosynthesis to convert CO2 to sugar, so rising CO2 levels make this easier to do
  - CO2 fertilisation changes the way plants allocate resources to growth vs reproduction, changing the nutrient content (particularly reducing protein and micronutrient contents)

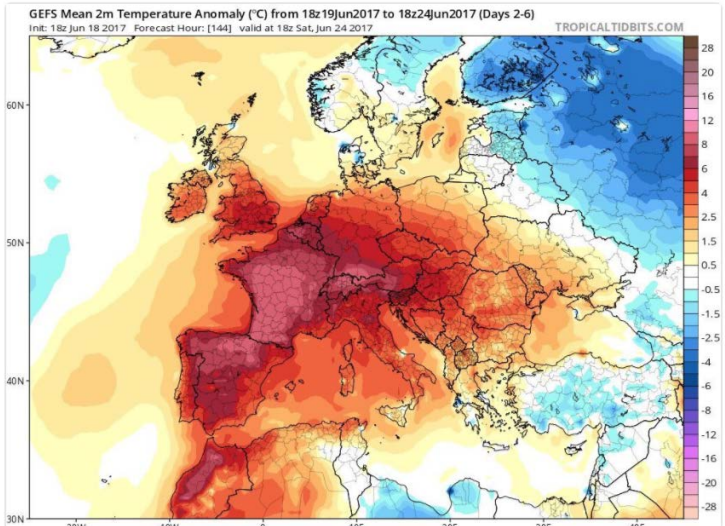
Of these, perhaps rising incidence of extremes will have biggest impacts





UN Climate Action
@UNFCCC
Follow

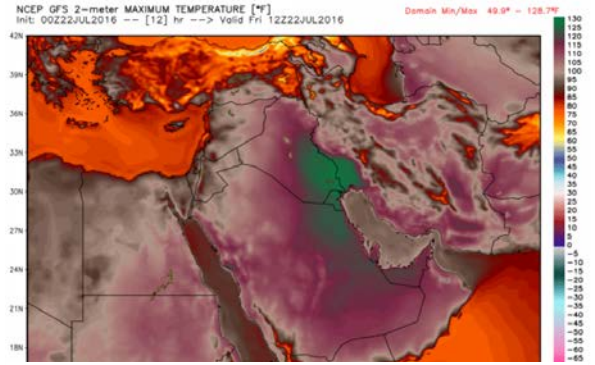
The approx 1°C global average temperature rise is translating into an approx 10°C + anomaly this week in France. Via @EKMeteo #climatechange



Capital Weather Gang

Two Middle East locations hit 129 degrees, hottest ever in Eastern Hemisphere, maybe the world

By Jason Samenow July 22, 2016



The temperature in Mitribah, Kuwait, surged Thursday to a blistering 129.2 degrees (54 Celsius). And on Friday in Basra, Iraq, the mercury soared to 129.0 degrees (53.9 Celsius). If confirmed, these

Food, land and climate

The land system: global demand for land

Category	Today
Total habitable land	10.4 Bha
Crop	1.5 Bha
Grazing	3.3 Bha
Forest managed	300 Mha
Forest natural	3.7 Bha
Scrub+semi-natural land	1.2 Bha
Urban	~360 MHa

Scale: Spain is 50.6 Mha

- About a quarter of ice-free land is degraded

- 120 Mha of **urban** expansion by 2030
- Consumes 46 Mha of highly productive cropland
- Sea-level rise: land lost + 13.1 m people in US displaced by 2100 (Hauer, 2017)

- 60-100% more **food** by 2050?
- Expansion typically on lower productivity lands
- 100 - 1,000 Mha more land by 2050 depending on assumptions

- 500 EJ per year of bioenergy by 2050?
- **Renewables** typically 10 to 3,000 times more land intensive

- 115 Mha of new land for **biomaterials/bioeconomy** by 2050

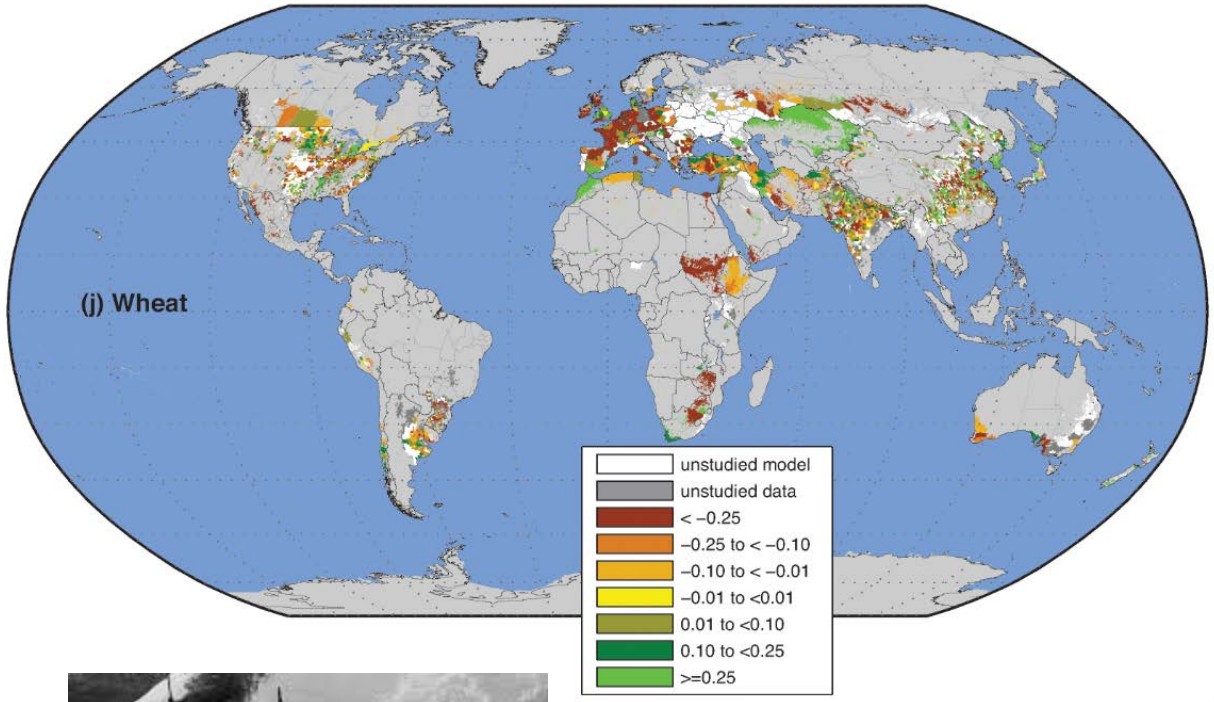
- new land by 2100 for Bioenergy with **carbon capture & storage** (BECCS)
- Afforestation and reforestation would require 970 Mha

Climate change is affecting food

Climate change is already...

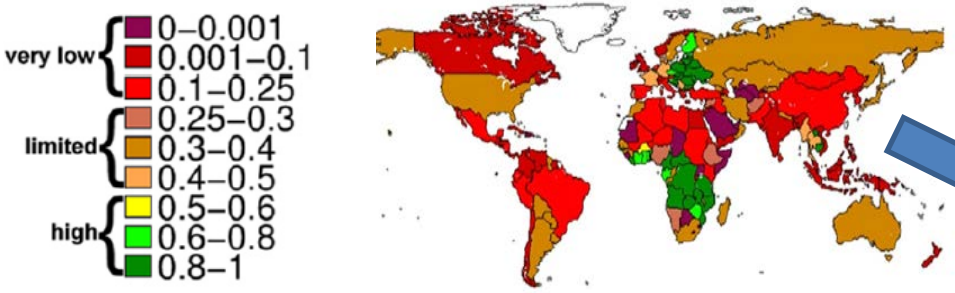
...disrupting:

- **Agriculture**, through increasing incidence of extreme weather (e.g. severe rainfall, drought, temperature) – affecting smallholder livelihoods in many places
  - Affecting both yields and nutrient contents
- **Infrastructure**, particularly through more severe storms (cyclones, hurricanes etc)
  - Including roads, dams, ports



Citation: Ray DK, West PC, Clark M, Gerber JS, Prishchepov AV, Chatterjee S (2019) Climate change has likely already affected global food production. PLoS ONE 14(5): e0217148. https://doi.org/10.1371/journal.pone.0217148

Interacting factors and price spikes



Environ. Res. Lett. **11** (2016) 055008

Internal feedbacks: Speculation, stock levels Trade policy changes (export bans, panic buying)

System Intensification pressure

Weather shocks
Pests, diseases
Input shocks
Regulatory shocks
Geopolitical shocks
trade wars or
e.g.
chokepoints

System shocks increasing

Markets, market rules and policies: Concentration, power, WTO, transparency

Impact: price spikes and volatility

Shocks from other sectors: oil, biofuel, politics, economy

(Homer-Dixon *et al.* 2015; Puma *et al.* 2015; Marianela *et al.* 2016; Philippe *et al.* 2016; Tadasse *et al.* 2016; Challinor, Adger & Benton 2017, Challinor et al, 2018)

Agriculture and food affect climate

The impacts of the sector on climate change: agriculture and food's emissions

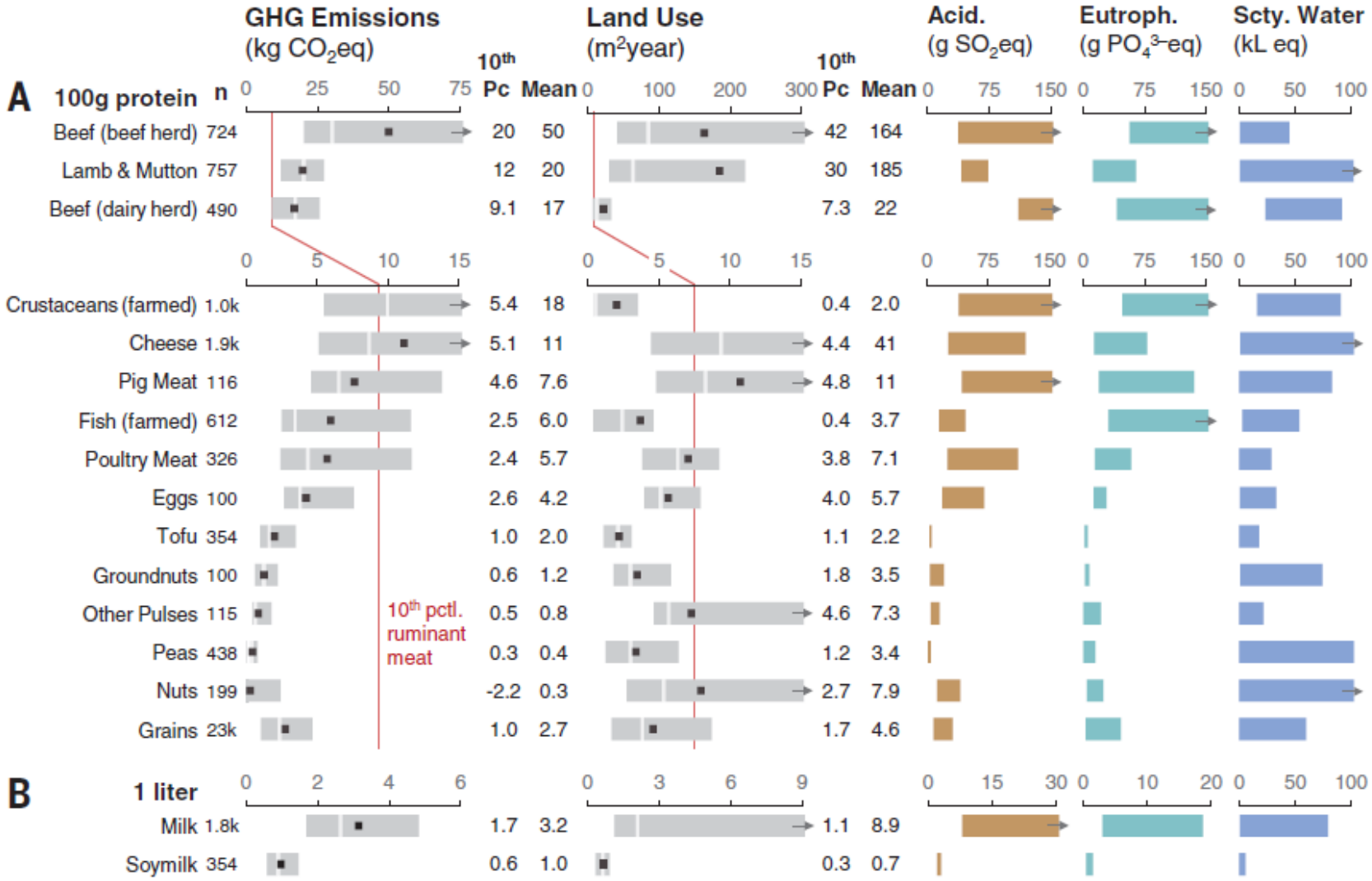
Source	Amount	Units
Global Anthropogenic GHGs	52.0±4.5	$GtCO_2e\ y^{-1}$ (over 2007-16)
Agricultural land use change	4.9±2.5	$GtCO_2\ y^{-1}$
Methane from cows and soils	4.0±1.2	$GtCO_2e\ y^{-1}$
Nitrous Oxide (fertiliser, manure)	2.2±0.7	$GtCO_2e\ y^{-1}$
Transport, manufacturing, cooking etc	2.4-4.8	$GtCO_2e\ y^{-1}$
Total	14.7 (10.7-19.1) 28.3(21-37)	$GtCO_2e\ y^{-1}$ % of total

Source: IPCC SRCCL Table SPM1

Livestock:

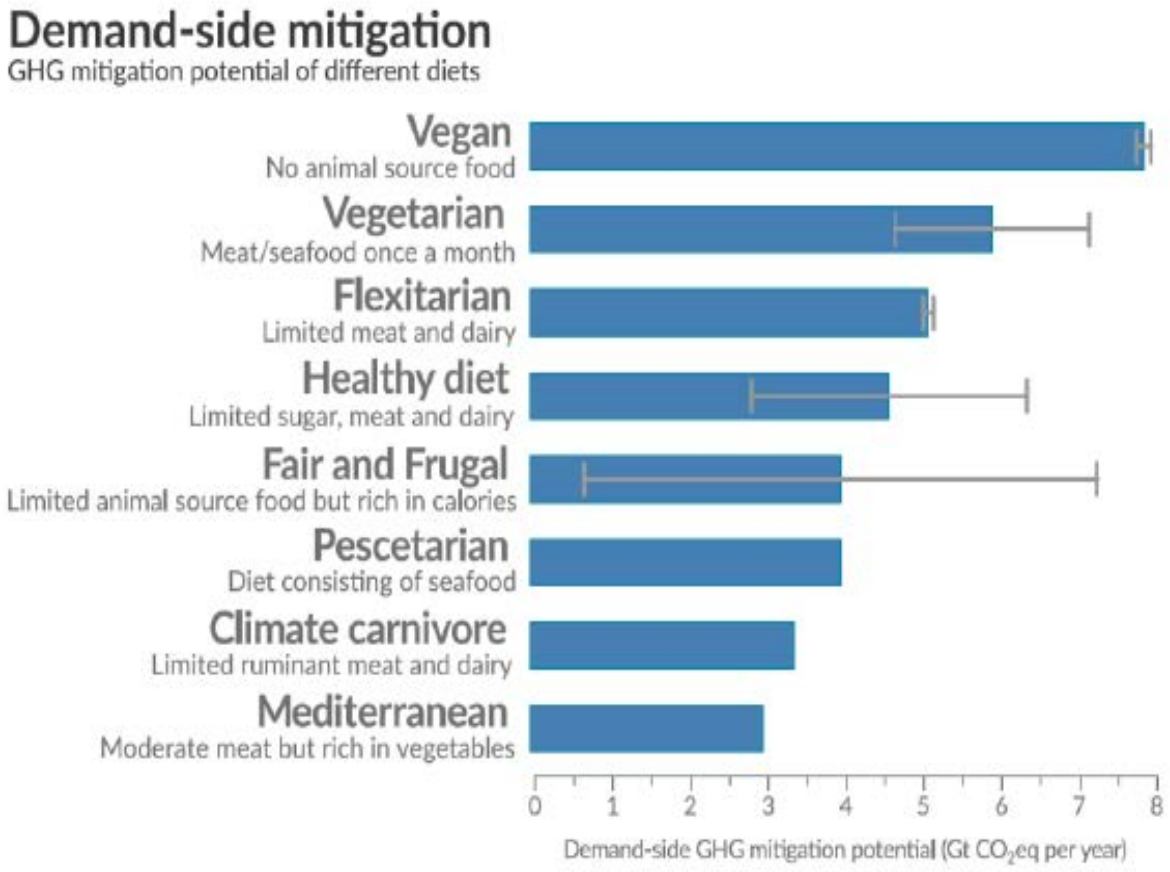
- 4.1 Gt direct emissions plus share of:
  - 4.9Gt for LUC
  - ~3.6Gt post-farm gate emissions
- ~50% total
  - of which ~3/4 from cattle

Footprints of food



Poore & Nemacek (2018)

IPCC SRCCL Message 1: Technical mitigation potential of dietary change

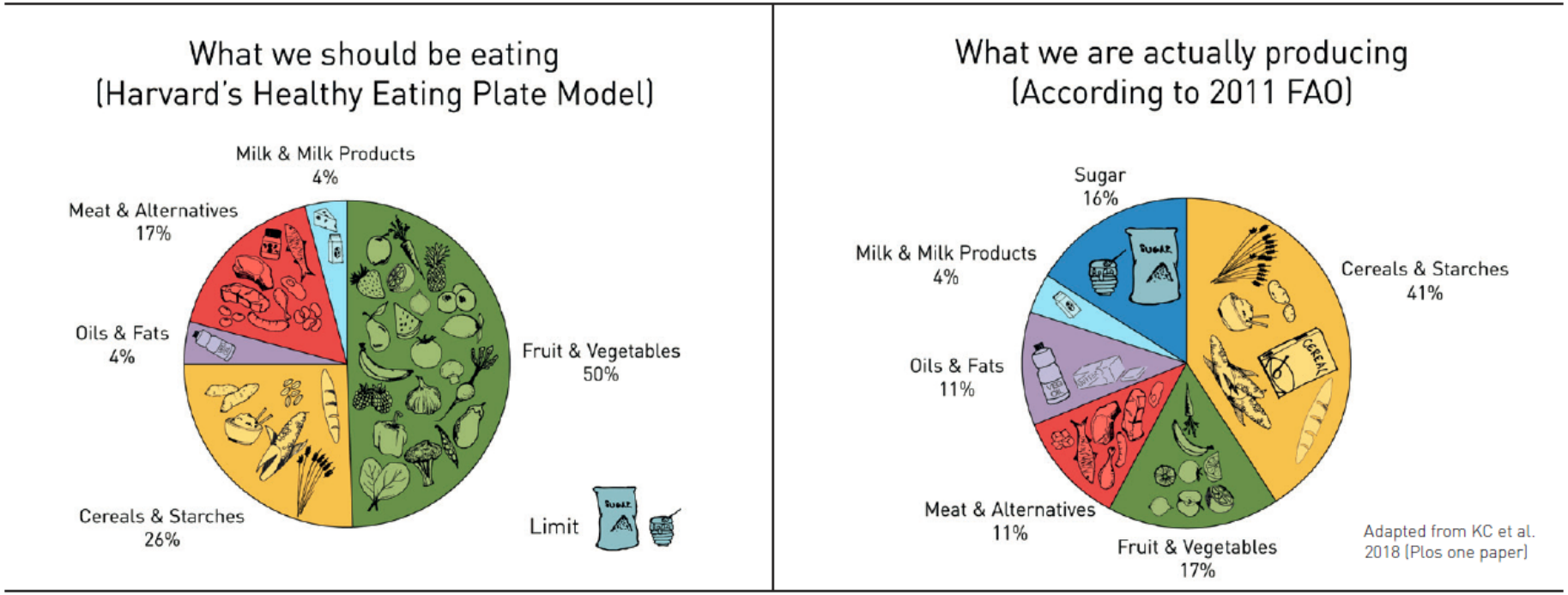


Total technical mitigation potential

0.2-2.4 GtCO2-eq yr-1 for livestock sector

Source: IPCC SRCCL Fig 5.12

We are not feeding the world nutritiously



To a first approximation, a diet with lots of fruit and vegetables, plant protein, less livestock produce, more whole grains and less ultra-processed foods (rich in calories) is both more healthy and has a lower footprint than diets currently consumed in HICs and many MICS.

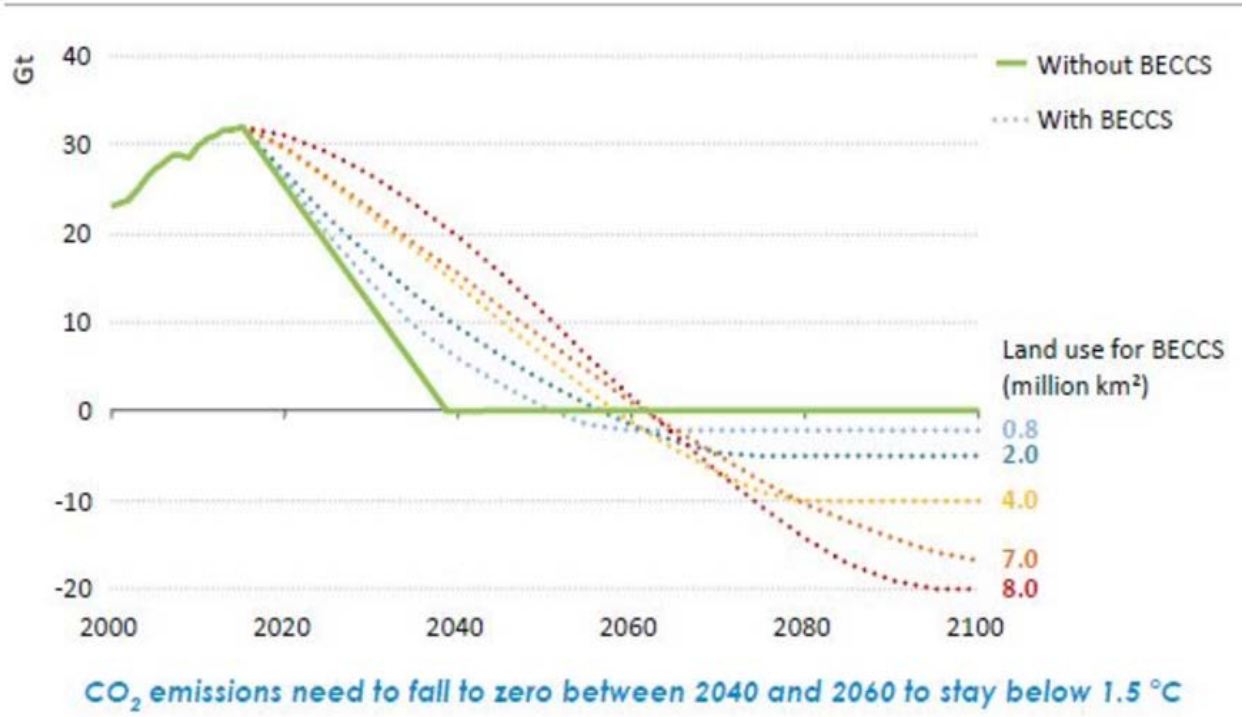
(EAT-Lancet, Obesity-Lancet, IPCC SRCCL, Springmann et al, Clarke et al, GloPan)

Mitigation and land use

IPCC SRCCL Message 2: Negative emissions technologies are risky but may be important

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

Figure 8.16 ▷ Energy sector CO_2 emission pathways consistent with a 1.5 °C temperature rise



IEA/OECD WEO 2016

Response options based on land management

		Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Agriculture	Increased food productivity	L	M	L	M	H	—
	Agro-forestry	M	M	M	M	L	●
	Improved cropland management	M	L	L	L	L	●●
	Improved livestock management	M	L	L	L	L	●●●
	Agricultural diversification	L	L	L	M	L	●
	Improved grazing land management	M	L	L	L	L	—
	Integrated water management	L	L	L	L	L	●●
	Reduced grassland conversion to cropland	L	—	L	L	– L	●
Forests	Forest management	M	L	L	L	L	●●
	Reduced deforestation and forest degradation	H	L	L	L	L	●●
Soils	Increased soil organic carbon content	H	L	M	M	L	●●
	Reduced soil erosion	↔ L	L	M	M	L	●●
	Reduced soil salinization	—	L	L	L	L	●●
	Reduced soil compaction	—	L	—	L	L	●
Other ecosystems	Fire management	M	M	M	M	L	●
	Reduced landslides and natural hazards	L	L	L	L	L	—
	Reduced pollution including acidification	↔ M	M	L	L	L	—
	Restoration & reduced conversion of coastal wetlands	M	L	M	M	↔ L	—
	Restoration & reduced conversion of peatlands	M	—	na	M	– L	●

Response options based on value chain management

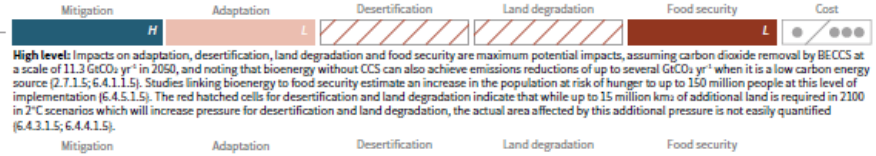
Demand	Reduced post-harvest losses	H	M	L	L	H	—
	Dietary change	H	—	L	H	H	—
	Reduced food waste (consumer or retailer)	H	—	L	M	M	—
Supply	Sustainable sourcing	—	L	—	L	L	—
	Improved food processing and retailing	L	L	—	—	L	—
	Improved energy use in food systems	L	L	—	—	L	—

Response options based on risk management

Risk	Livelihood diversification	—	L	—	L	L	—
	Management of urban sprawl	—	L	L	M	L	—
	Risk sharing instruments	↔ L	L	—	↔ L	L	●●

Options shown are those for which data are available to assess global potential for three or more land challenges. The magnitudes are assessed independently for each option and are not additive.

Bioenergy and BECCS



High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts, assuming carbon dioxide removal by BECCS at a scale of 11.3 $GtCO_2\ yr^{-1}$ in 2050, and noting that bioenergy without CCS can also achieve emissions reductions of up to several $GtCO_2\ yr^{-1}$ when it is a low carbon energy source (2.7.1.5; 6.4.1.1.5). Studies linking bioenergy to food security estimate an increase in the population at risk of hunger to up to 150 million people at this level of implementation (6.4.5.1.5). The red hatched cells for desertification and land degradation indicate that while up to 15 million km_2 of additional land is required in 2100 in 2°C scenarios which will increase pressure for desertification and land degradation, the actual area affected by this additional pressure is not easily quantified (6.4.3.1.5; 6.4.4.1.5).

Best practice: The sign and magnitude of the effects of bioenergy and BECCS depends on the scale of deployment, the type of bioenergy feedstock, which other response options are included, and where bioenergy is grown (including prior land use and indirect land use change emissions). For example, limiting bioenergy production to marginal lands or abandoned cropland would have negligible effects on biodiversity, food security, and potentially co-benefits for land degradation; however, the benefits for mitigation could also be smaller. (Table 6.5B)

Reforestation and forest restoration

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of reforestation and forest restoration (partly overlapping with afforestation) at a scale of 10.1 $GtCO_2\ yr^{-1}$ removal (6.4.1.1.2). Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people; the impact of reforestation is lower (6.4.5.1.2).

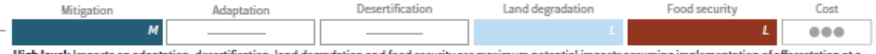
Best practice: There are co-benefits of reforestation and forest restoration in previously forested areas, assuming small scale deployment using native species and involving local stakeholders to provide a safety net for food security. Examples of sustainable implementation include, but are not limited to, reducing illegal logging and halting illegal forest loss in protected areas, reforesting and restoring forests in degraded and desertified lands (Box6.1C; Table 6.6).

Afforestation

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation (partly overlapping with reforestation and forest restoration) at a scale of 8.9 $GtCO_2\ yr^{-1}$ removal (6.4.1.1.2). Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people (6.4.5.1.2).

Best practice: Afforestation is used to prevent desertification and to tackle land degradation. Forested land also offers benefits in terms of food supply, especially when forest is established on degraded land, mangroves, and other land that cannot be used for agriculture. For example, food from forests represents a safety-net during times of food and income insecurity (6.4.5.1.2).

Biochar addition to soil



High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation at a scale of 6.6 $GtCO_2\ yr^{-1}$ removal (6.4.1.1.3). Dedicated energy crops required for feedstock production could occupy 0.4–2.6 Mkm^2 of land, equivalent to around 20% of the global cropland area, which could potentially have a large effect on food security for up to 100 million people (6.4.5.1.3).

Best practice: When applied to land, biochar could provide moderate benefits for food security by improving yields by 25% in the tropics, but with more limited impacts in temperate regions, or through improved water holding capacity and nutrient use efficiency. Abandoned cropland could be used to supply biomass for biochar, thus avoiding competition with food production; 5-9 Mkm^2 of land is estimated to be available for biomass production without compromising food security and biodiversity, considering marginal and degraded land and land released by pasture intensification (6.4.5.1.3).

Key for criteria used to define magnitude of impact of each integrated response option

		Mitigation *Gt CO_2-eq yr^{-1}*	Adaptation *Million people*	Desertification *Million km^2*	Land Degradation *Million km^2*	Food Security *Million people*
Positive	Large	More than 3	Positive for more than 25	Positive for more than 3	Positive for more than 3	Positive for more than 100
	Moderate	0.3 to 3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
	Small	Less than 0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Negligible	No effect	No effect	No effect	No effect	No effect
Negative	Small	Less than -0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Moderate	-0.3 to -3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
	Large	More than -3	Negative for more than 25	Negative for more than 3	Negative for more than 3	Negative for more than 100

↔ **Variable:** Can be positive or negative — no data — na not applicable

Confidence level
Indicates confidence in the estimate of magnitude category.
H High confidence
M Medium confidence
L Low confidence

Cost range
See technical caption for cost ranges in US$ tCO_2e^{-1} or US$ ha^{-1}.
●●● High cost
●● Medium cost
● Low cost
— no data

Source: IPCC SRCCL Fig SPM2

There is no silver bullet to decarbonise the food system

- Total technical supply side and demand side mitigation is approximately equal
- Many policy interventions possible
- Trade may be an enabler or disabler

IPCC SRCCL T5.6

family	**Intervention**
Increasing agricultural efficiency and yields	Agricultural R&D
	Supporting precision agriculture
	Sustainable intensification
	Improving farmer training and sharing via extension services, online access, field schools, farmer-to-farmer, etc
	Targeting public money invested in production towards pro-environmental/pro-nutrition outcomes
Smarter land use	Land use planning underpinned by remote sensing and/or ILK
	Agri-environment schemes
	Payment for ecosystem service schemes
Market	Mandated reporting of company externalised costs in supply chains.
	Market-led, or government-subsidised, insurance products to drive behaviour
	Stimulating "premium markets" e.g. organic food
Trade	Liberalising trade flows under socio-ecological principles to drive comparative advantage (WTO rules; trade agreements)
Reducing waste	Regulations to reduce and taxes on food waste
	Awareness campaigns/education
	Improving shelf life (biological intervention, packaging, cold-storage etc)
	Circularising the economy to use waste to produce goods which substitute
Reducing consumption of products associated with externalised costs	Changing food choice through nudge
	Changing pricing through Pigouvian taxes e.g. carbon pricing, or sugar/fat taxes to reduce excess consumption
	Changing food choices through money transfers
	Changing food environments through planning
	Changing subsidies/standards/regulations to promote healthier foods (fruit vs cereal bars) or more sustainably produced foods
	Preventative vs curative public health care incentives: health insurance reductions through better diets (including lower consumption)
	Personalised nutrition
	Creating greater transparency of food's impacts as a means of changing consumption
	Nutrition and sustainability education and awareness campaigns
	Investment in disruptive technology to encourage switch to food with lower environmental footprint (e.g. "clean meat")
	Public procurement to stimulate new ways of producing food, or different types of diet. Whilst most commonly for health reasons, there are examples of mandated procurement of "sustainably produced foods"

Discussion points

- Living in anything like “safe” climate change may require dietary change in many countries
  - To reduce emissions directly
  - To reduce land pressure and allow possibility of NETS
  - “zero net carbon” is perhaps a bigger challenge than “zero carbon”
- Co-benefits from improved health potentially greater than transition costs
  - Societal costs of poor diets in UK >5x greater than agricultural GVA
- How best to achieve low carbon food systems will change with future of trade
  - ~40-50% of what UK eats is imported
  - Could have UK *zero net carbon* land use but increased emissions overseas; or low-emissions diets but high emissions UK land use
- In the meantime, the global food system is increasingly fragile to shocks; and competition for land is increasing

Thank you

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