


Can we feed the world and still save the planet?

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Can we feed the world and still save the planet?



Feeding the world
Agriculture and land use
Agriculture and climate change
Innovations to meet the challenge

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Feeding the world

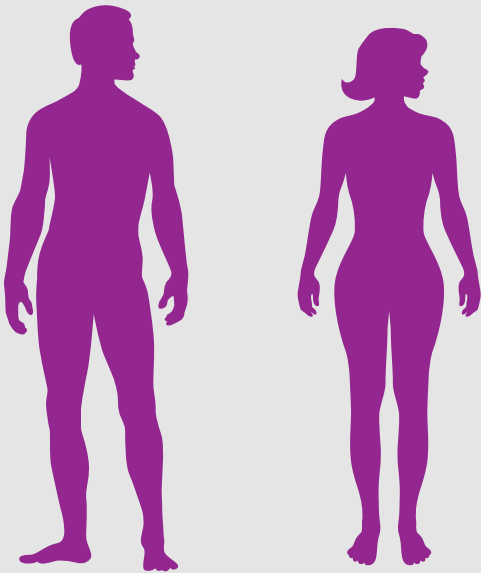
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Humans need energy from food to survive



For low levels of physical activity per day when aged 31-35:

women need
8,400 kJ

men need
10,900 kJ

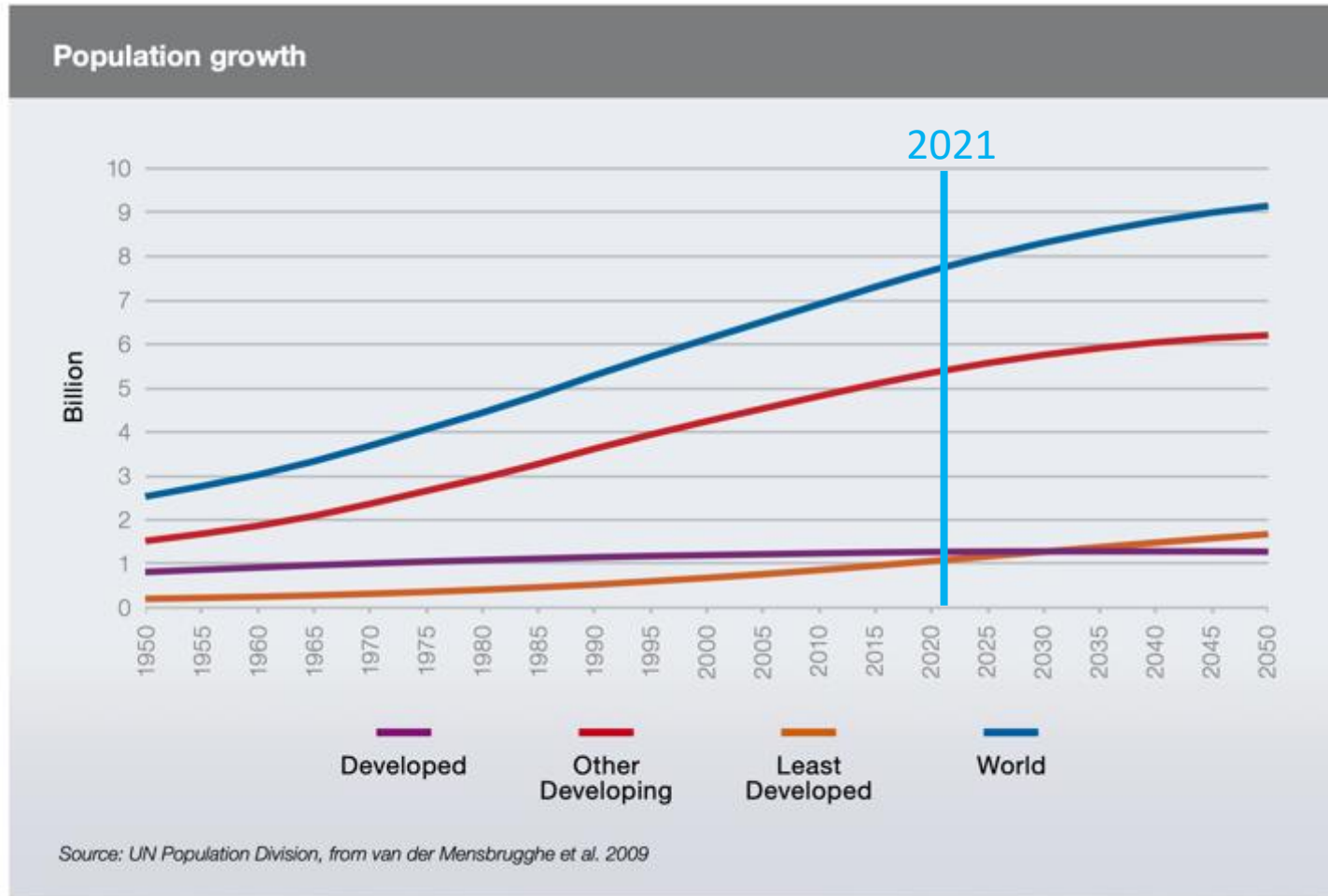
US and French governments

UN Food and Agriculture organization states:
the minimum energy required per day just to survive = 7,500 kJ



Equivalent to
1.4 Kg of cooked
white rice

World population is 7.9 billion people (7,900,000,000) in 2021



World population is predicted to reach 9 billion by 2050

A **15% increase in food production will be needed by 2050**, and **40% by 2100** to feed these extra people,

Predictions of food shortage and starvation were made in the past

Thomas Malthus (1798) "An essay on the principle of population"

Population growth exponential

Food supply increase linear

**When population exceeds food supply—
people will starve**

Paul Erlich (1968) "The population time bomb"

"in the 1970s hundreds of millions of **people will starve to death** in spite of any crash programs embarked upon now."¹

They were wrong !

The world population has continued to grow beyond the level thought possible by these scientists.



18th Century

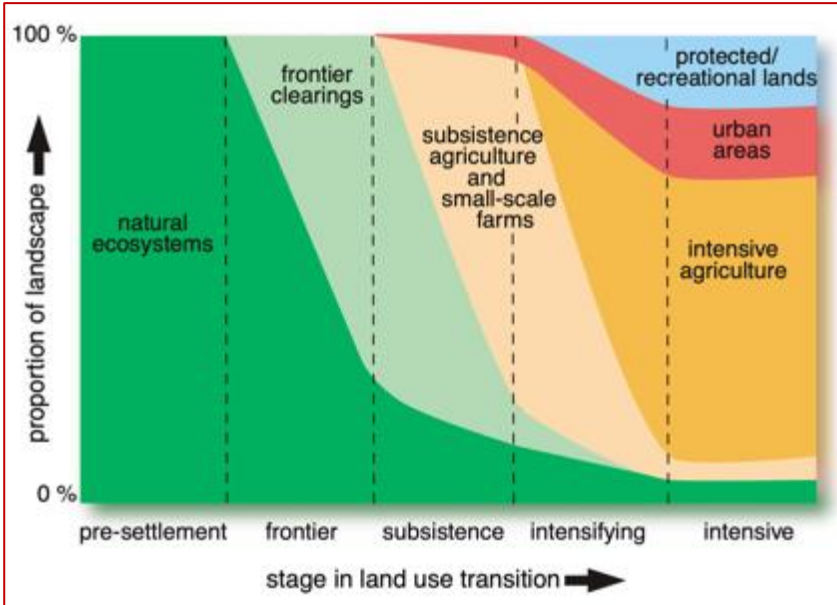


20th Century

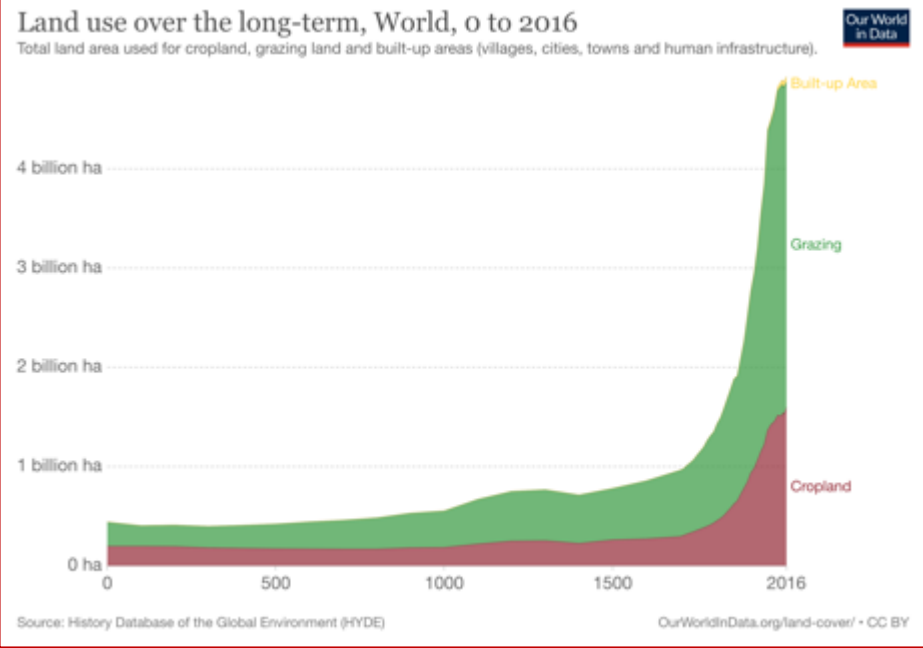
Farm Land area has increased to increase production

As human societies have developed they have changed natural ecosystems into farmed land.

Changes in land use

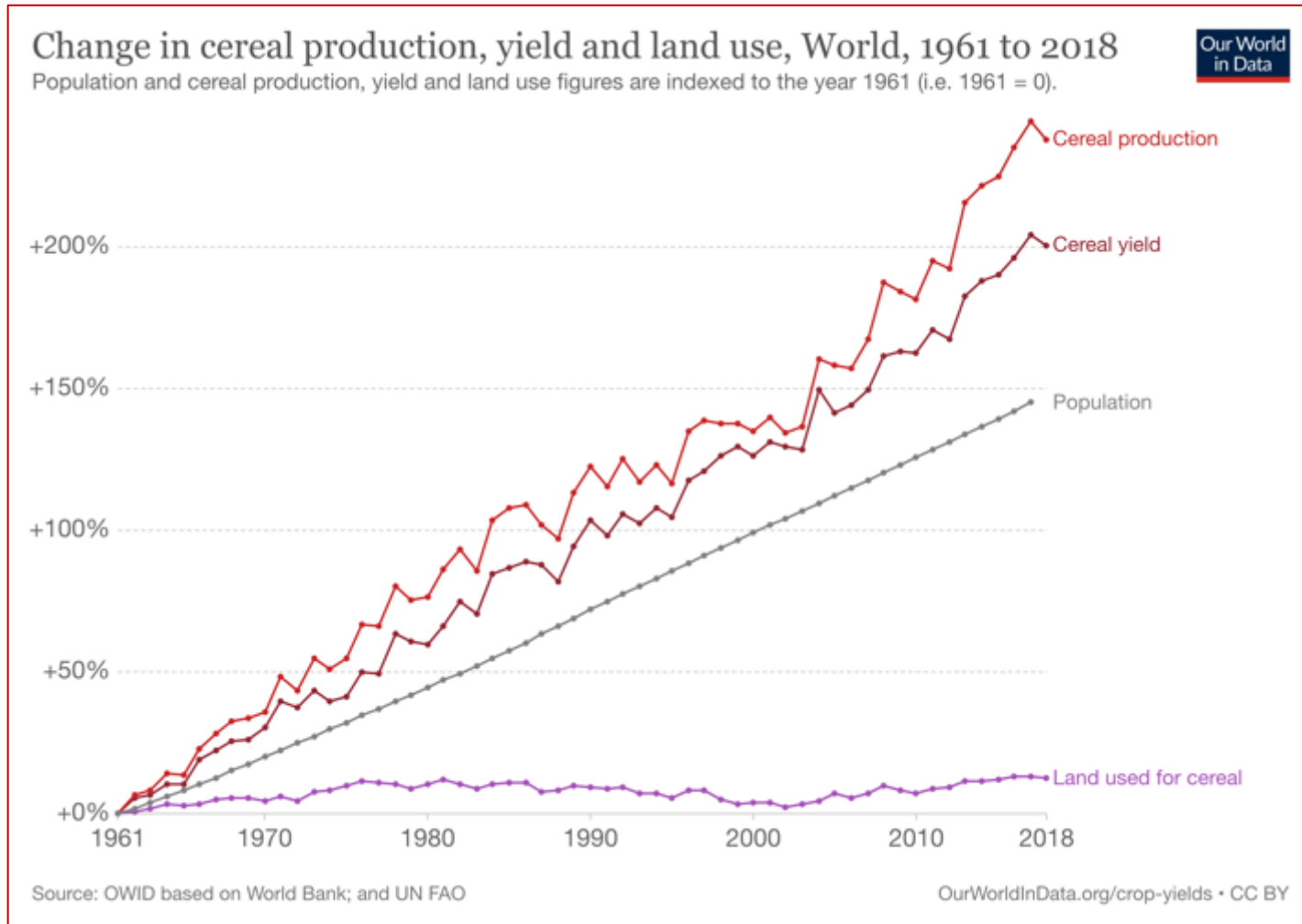


Foley et al Science (2005) 309 570-574



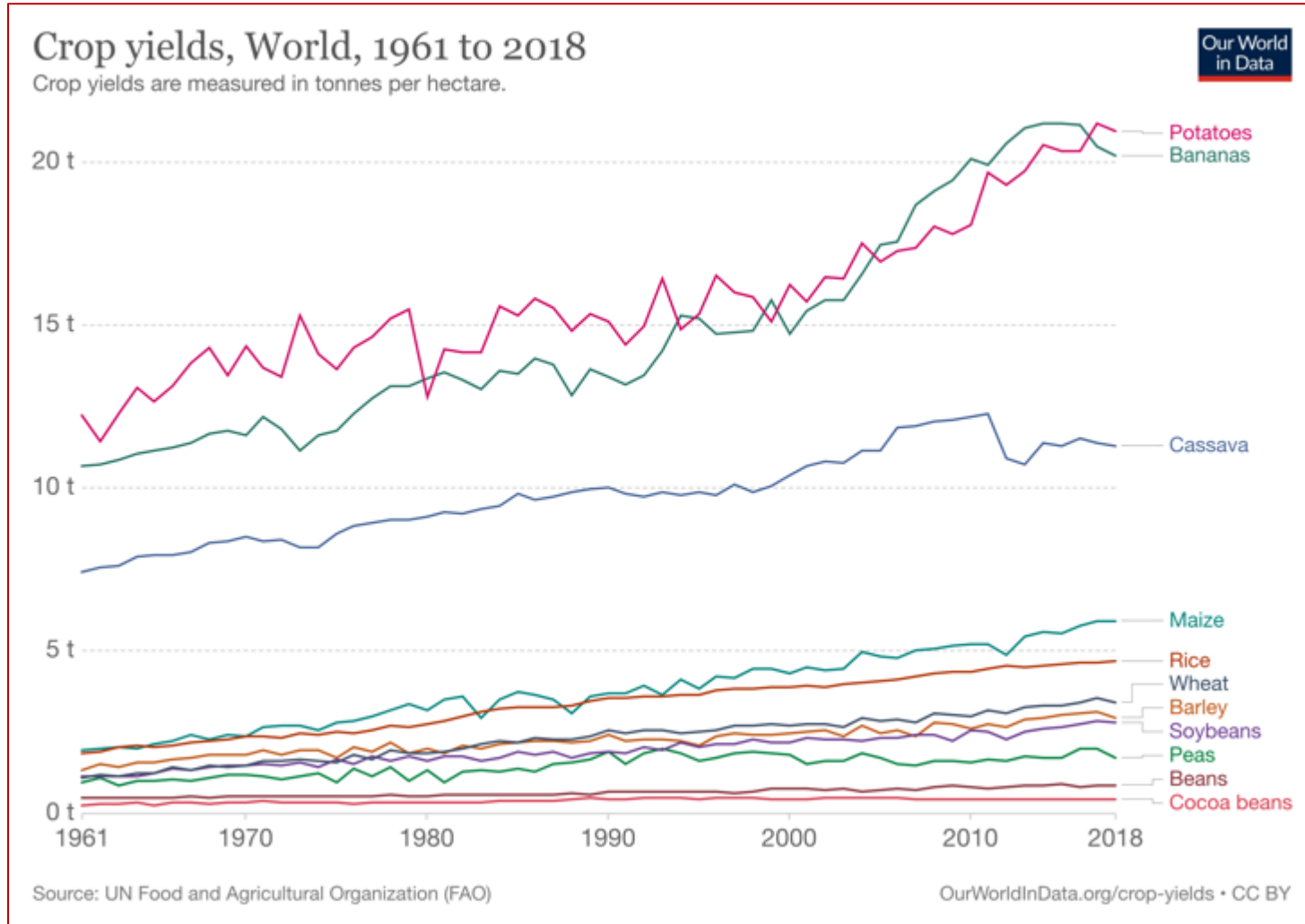
However, the increased area of land used for agriculture is not enough to provide food for the increased number of people now living on earth.

Increases in crop production have exceeded increases in population growth

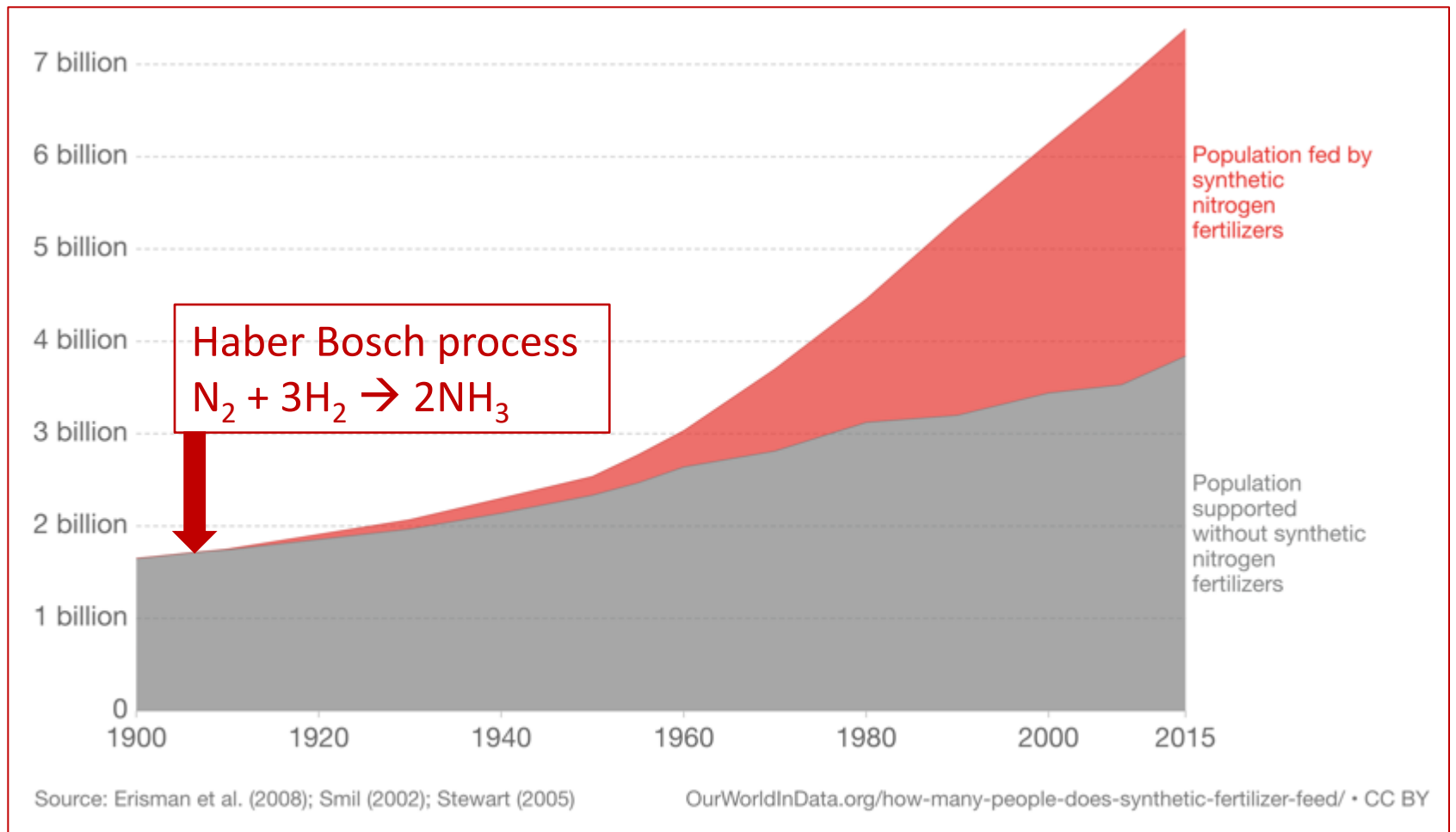


More crops are now produced from the same area of farmland, largely because of the development and use of nitrogen fertilisers.

Productivity of most food crops has increased

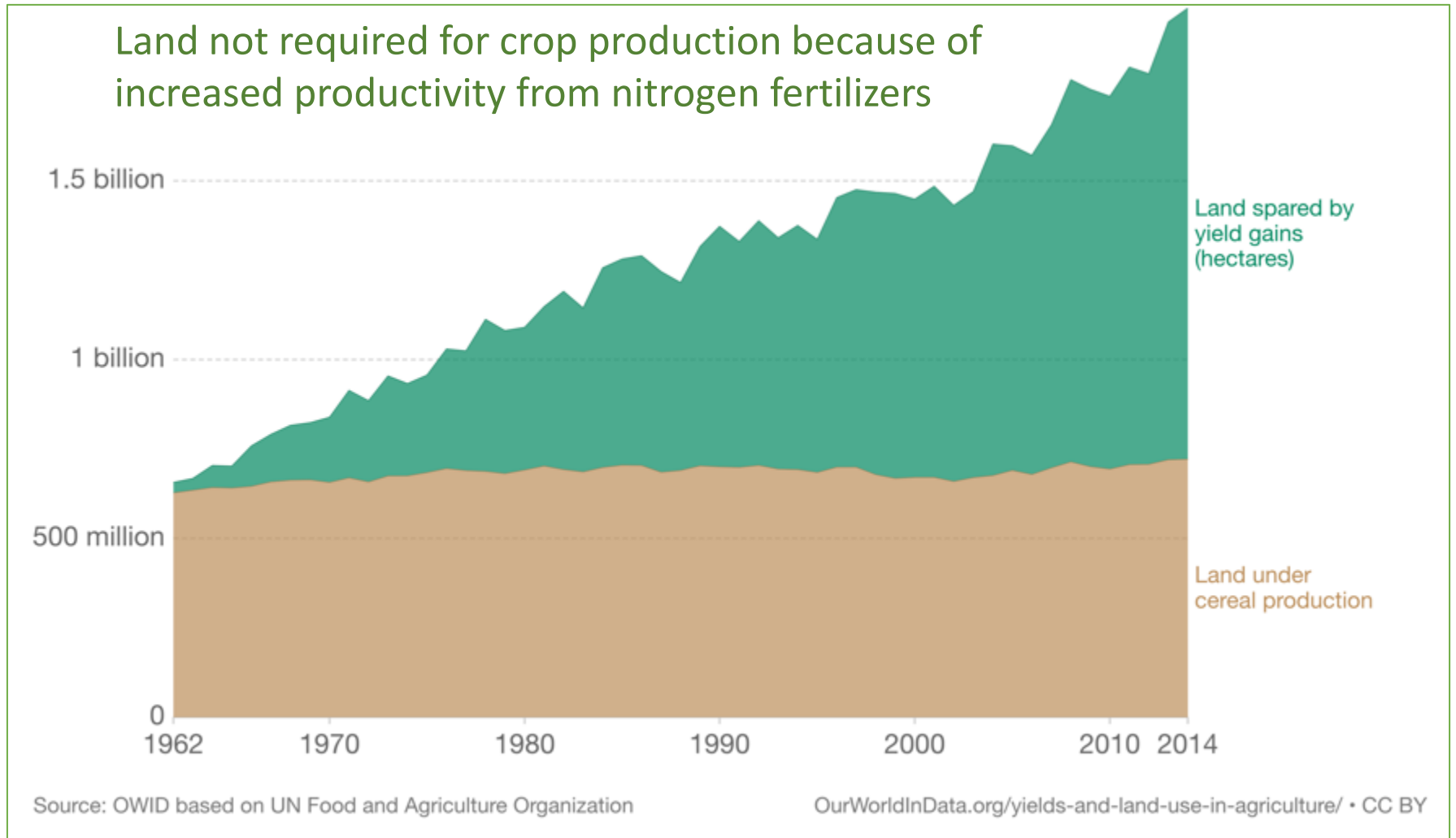


Almost Half the worlds population is fed by synthetic Nitrogen fertilizers



Development of the Haber Bosch process in the early 20th Century, which creates ammonia from nitrogen in the air, made widespread use of synthetic Nitrogen fertilizers possible

Without artificial nitrogen fertilizers, the area of land used for farming would need to more than double.



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Feeding the world

Agriculture and land use

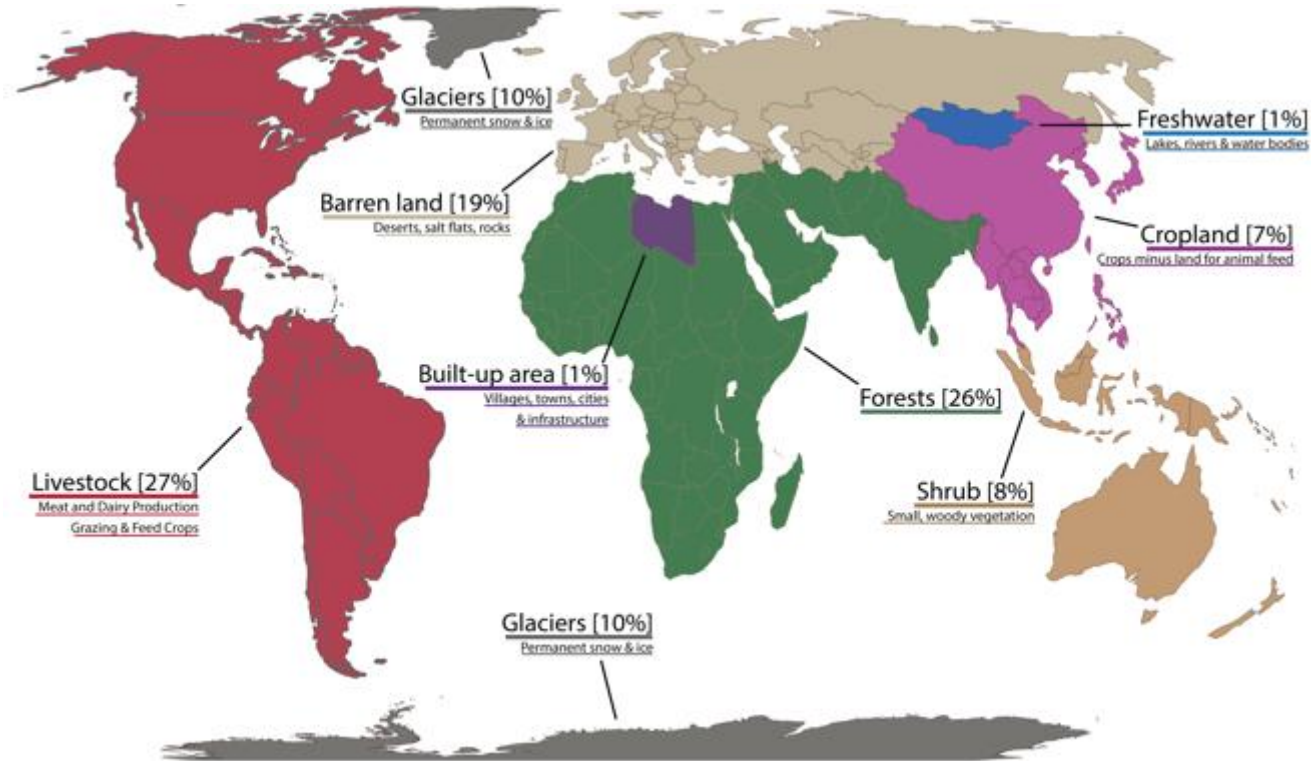
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Forests are the main type of land suitable for agriculture

World Land use mapped onto the continents to show relative areas

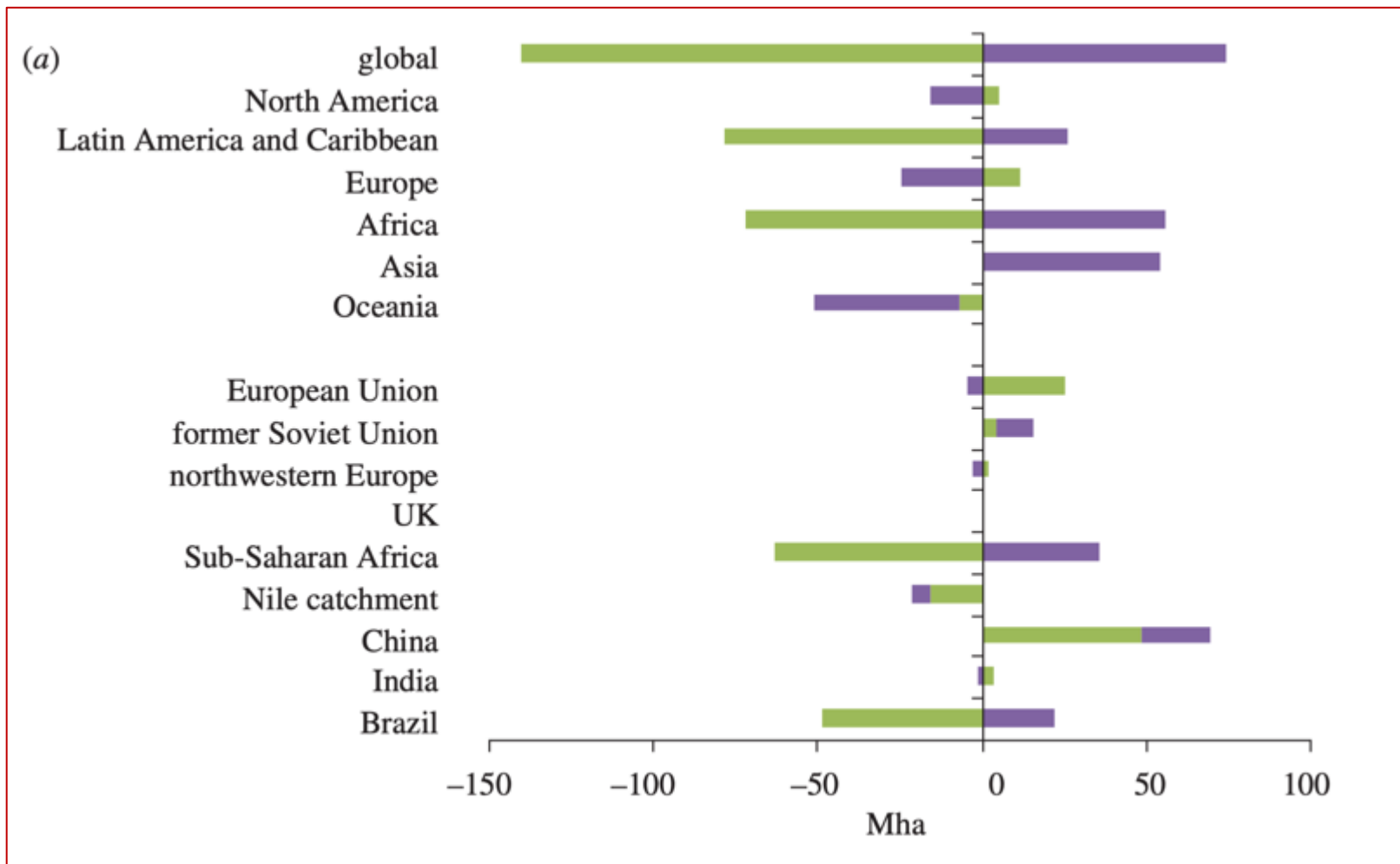


Based on data by the UN Food and Agricultural Organization (FAO) and World Bank Statistics. This map is based on the equal-area Eckert IV map projection. The data visualization is available at [OurWorldInData.org](https://ourworldindata.org). There you find research and more visualizations on this topic.

Licensed under CC-BY-SA by the authors Hannah Ritchie and Max Roser.

Only forests contain fertile land suitable for agriculture. To increase the area of agricultural land available will need the destruction of the forested areas.

In most regions increases in agricultural land area is accompanied by decrease in forested area.

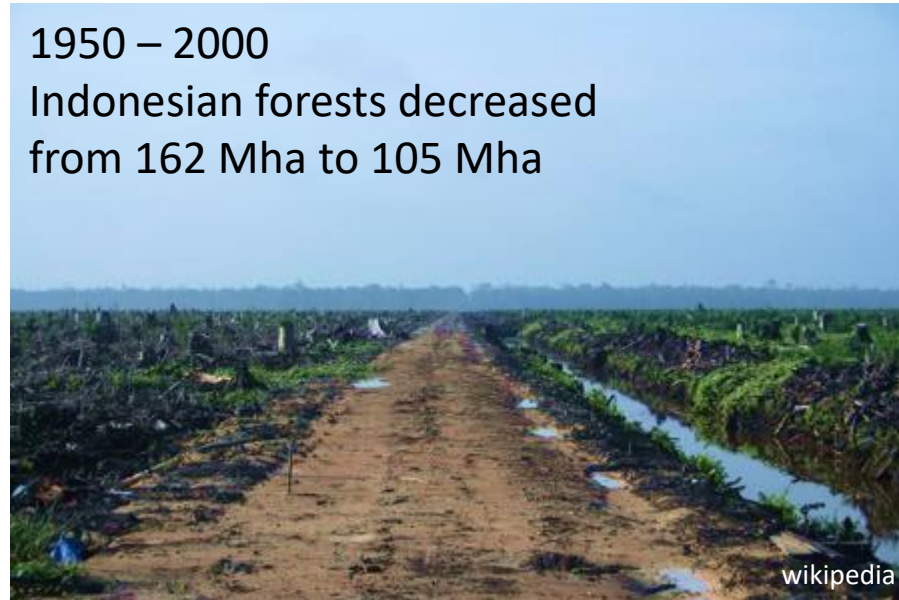


Land use issues are often complex

Indonesia contains a large proportion of the world's plant, animal and bird species. 1.3% of land, 10% of mammal species. Most live in the forests.



1950 – 2000
Indonesian forests decreased from 162 Mha to 105 Mha



Much of the forest area in Indonesia has been used for **Palm oil production.**

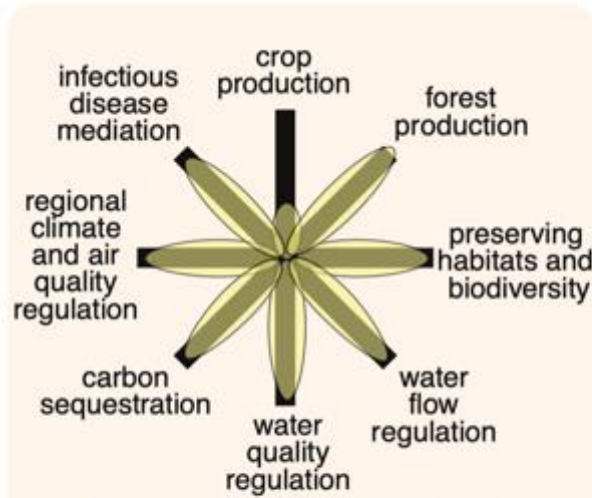
However, **stopping palm oil use would lead to a need for greater areas of land** to produce the equivalent oil yield from other crops.



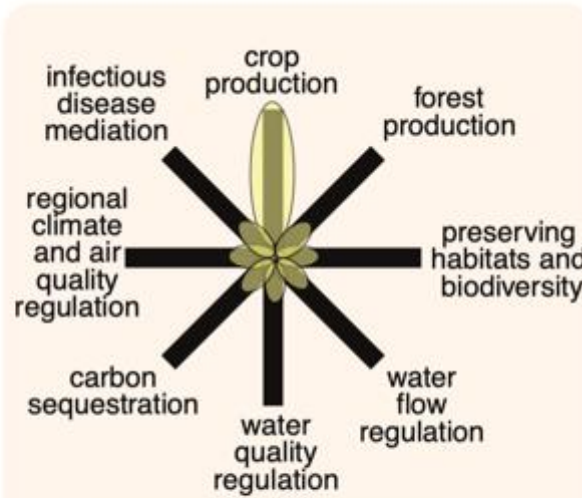
Comparison of global oil yields by crop plant
Oil yields in tonnes per hectare (t/ha)



Using land for agriculture often has adverse environmental impacts

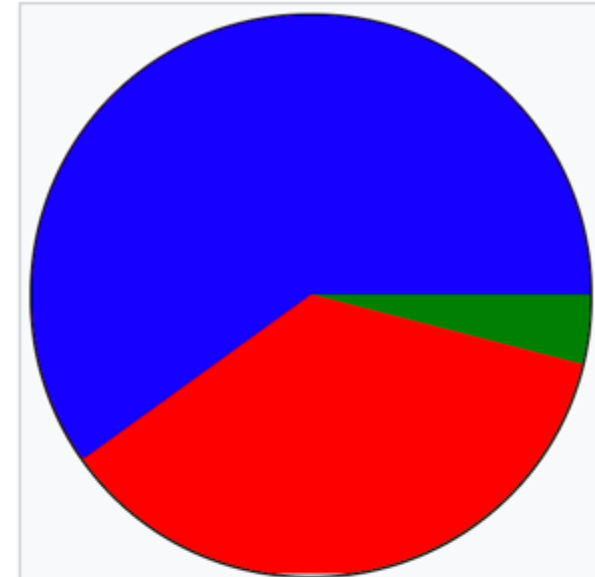


natural ecosystem



intensive cropland

Foley et al Science (2005) 309: 570-574




Biomass of mammals on Earth^{[141][142]}

- Livestock, mostly cattle and pigs (60%)
- Humans (36%)
- Wild animals (4%)

Loss of biodiversity may also impact our ability to find new sources of drugs for medical use or wild plant species with useful traits for agriculture such as drought resistance.

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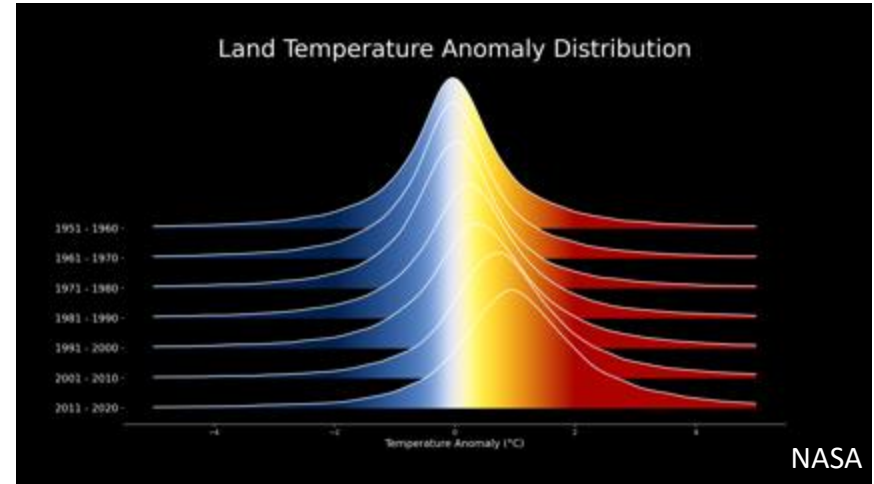


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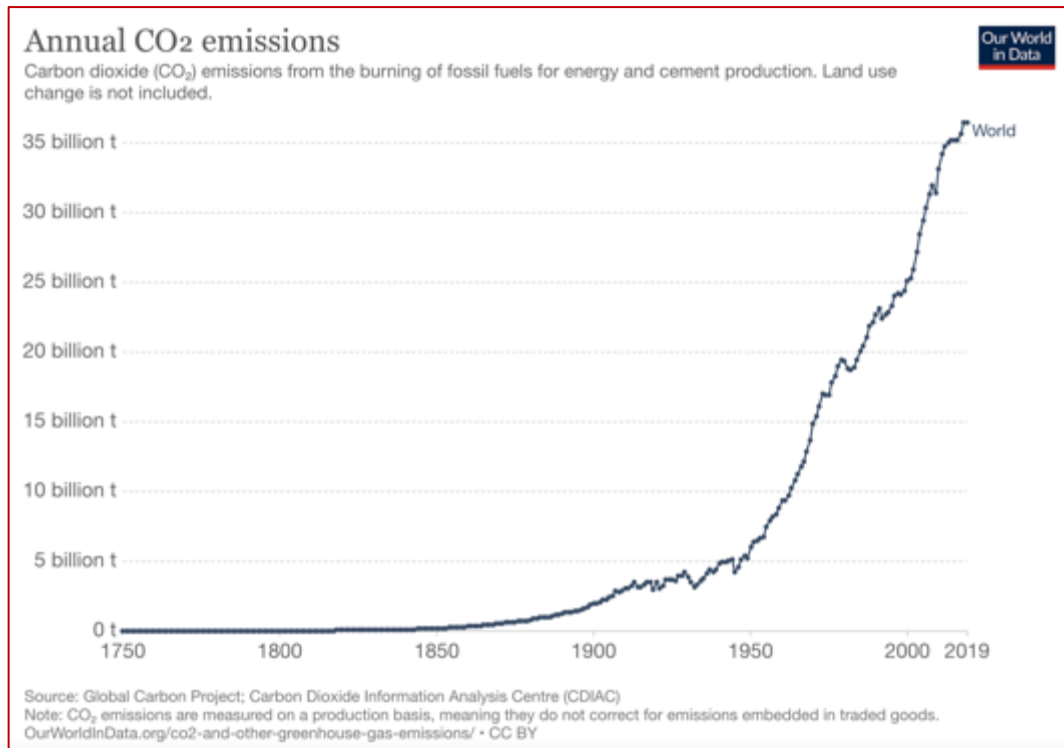
Greenhouse gases from human activities are linked to climate change



The number of extreme weather events including unusually high temperatures has increased.



Emissions of carbon dioxide and other greenhouse gases has increased since the 18th Century, when modern industrialisation began.



Climate activists are now calling for changes in agriculture



wikipedia

Greta Thunberg has led world wide protests by school students and addressed the UN Climate action summit in 2019, calling on governments to take action on climate change.

"Climate activist Greta Thunberg takes on food industry". *Deutsche Welle*. 23 May 2021.

"In May 2021, she addressed the COVID-19 crisis again, when she urged a change in the food production system and the protection of animals and their habitats."

Climate activists and organisations such as the World wide fund for Nature (WWF) are increasingly focussing on agriculture as a cause of climate change and loss of animal and plant diversity.

"WWF's work has evolved from saving species and landscapes to addressing the larger global threats and forces that impact them". WWF

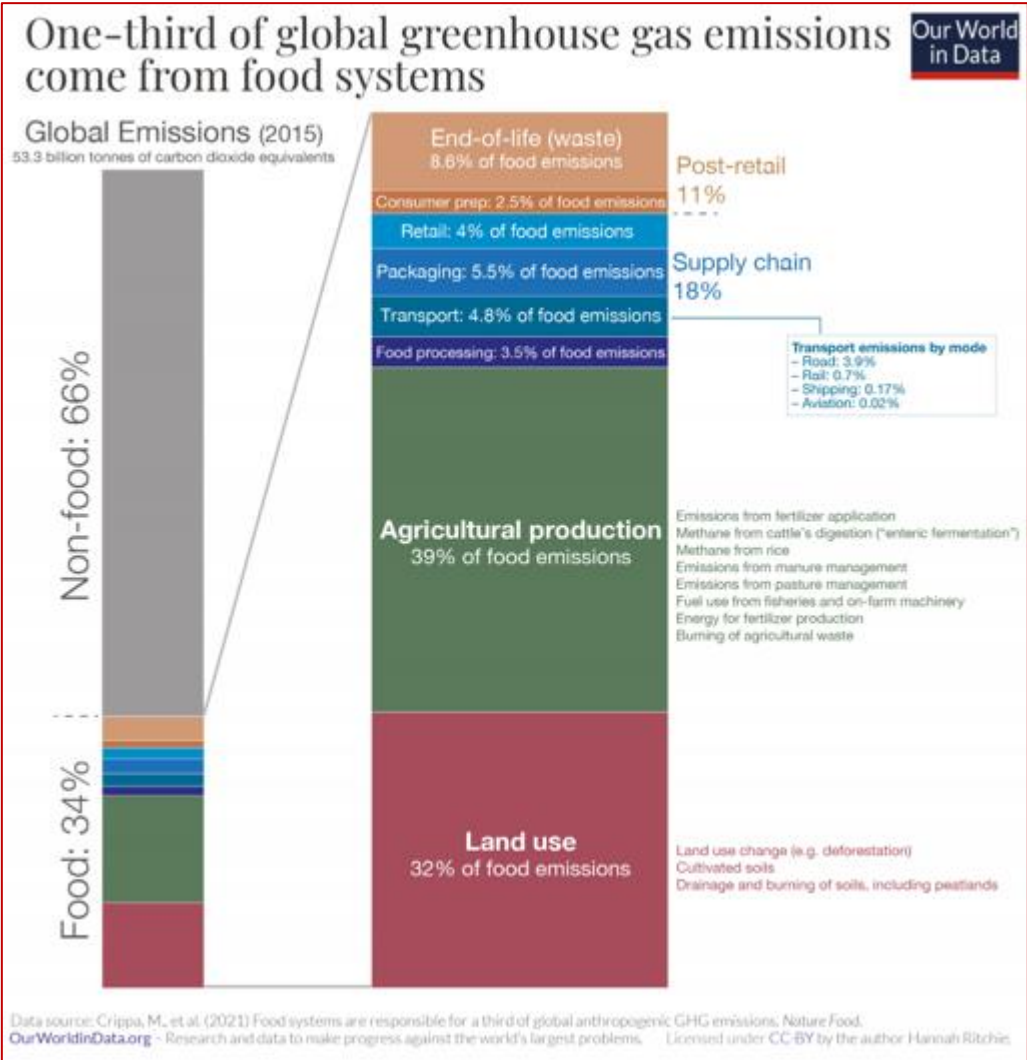
Agriculture and food production produces 34% of emissions

Agriculture produces one third of the world's greenhouse gas emissions.

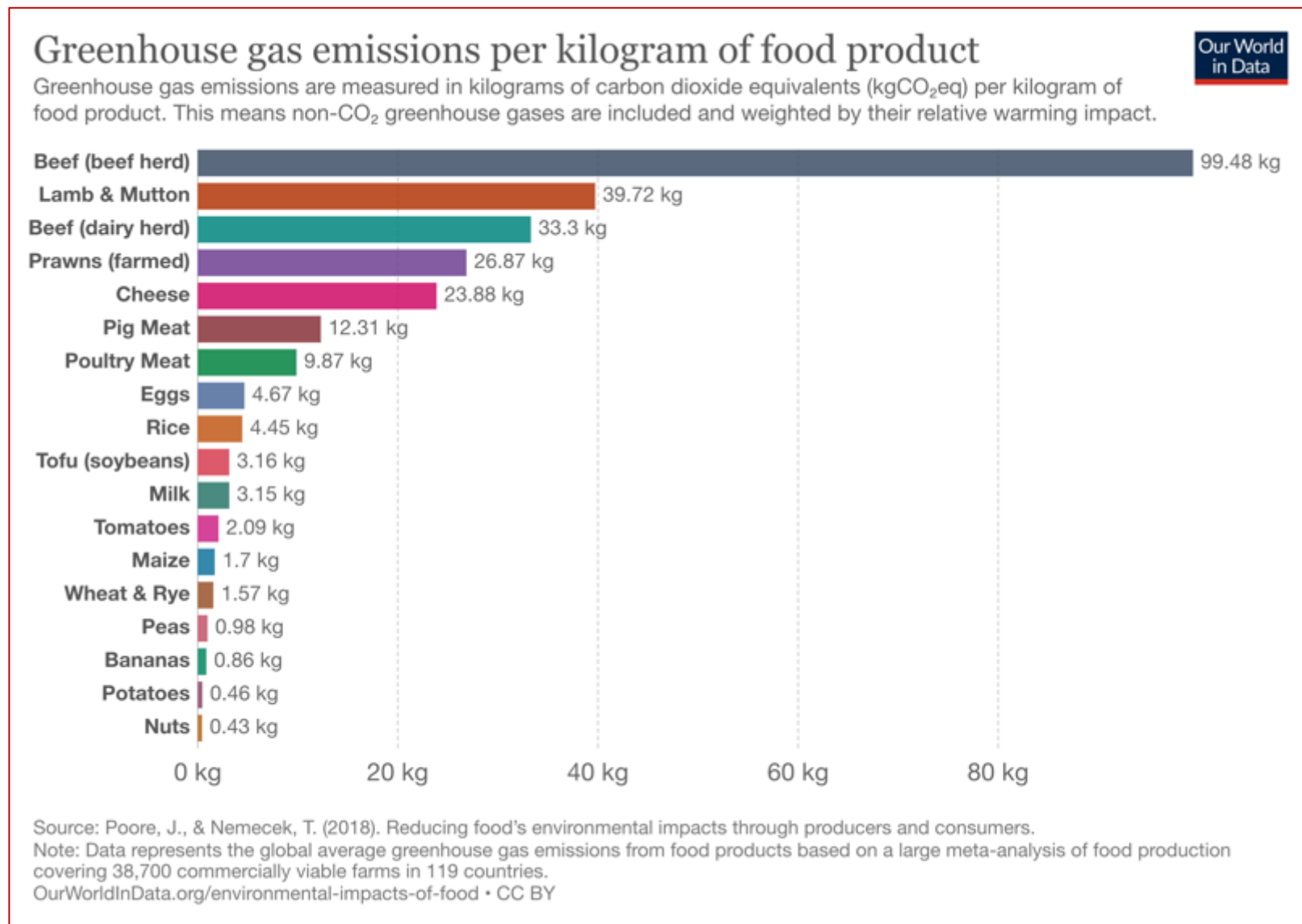
Food transport is only 1.6 % of the total.

	Billion tCO ₂ eq
Global	50
Agriculture	5-6
Methane	(3.3)
N ₂ O	(2.8)
Forestry	8-10
Deforestation	(5-6)
Decay and peat	(3-4)
Total agriculture and forestry	13-15

UN FAO (2011) "THE STATE OF THE WORLD'S LAND AND WATER RESOURCES FOR FOOD AND AGRICULTURE"

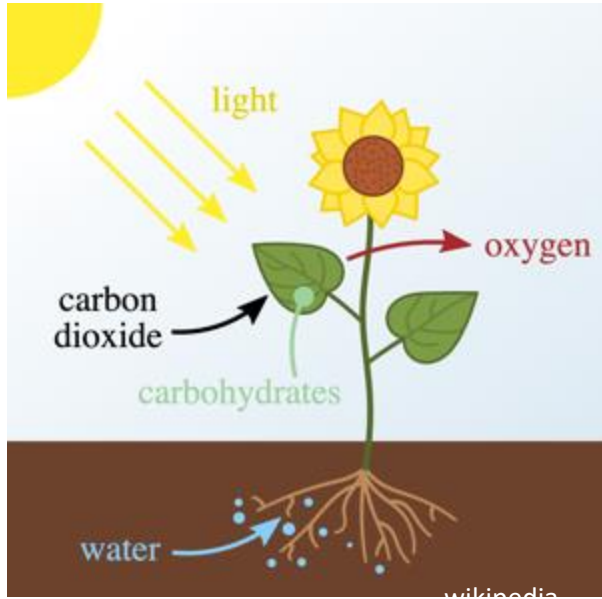


Meat products produce the highest levels of greenhouse gas emissions

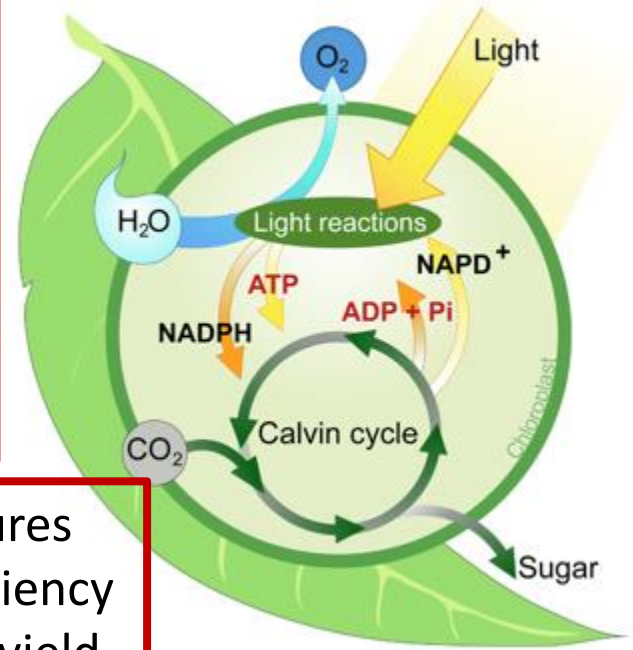


Rice and Soybeans have the highest crop emissions

Extra CO₂ in the atmosphere may not improve crop productivity

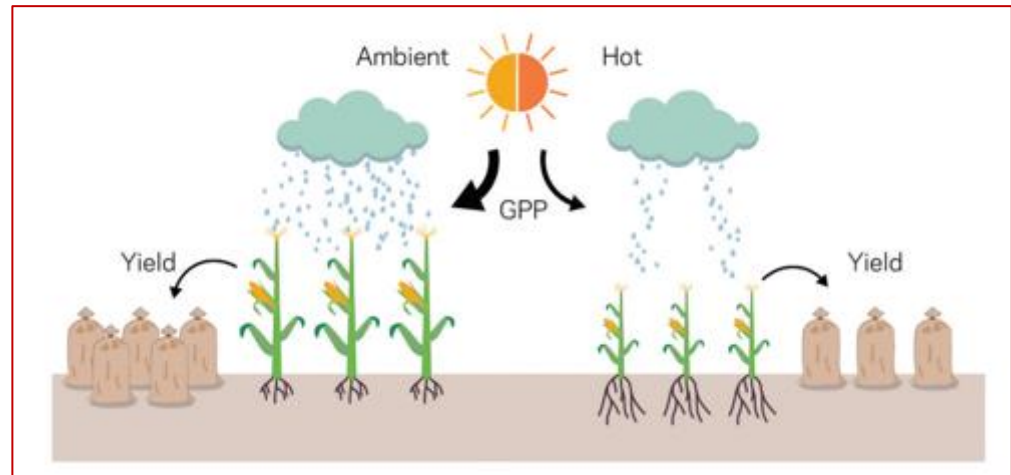
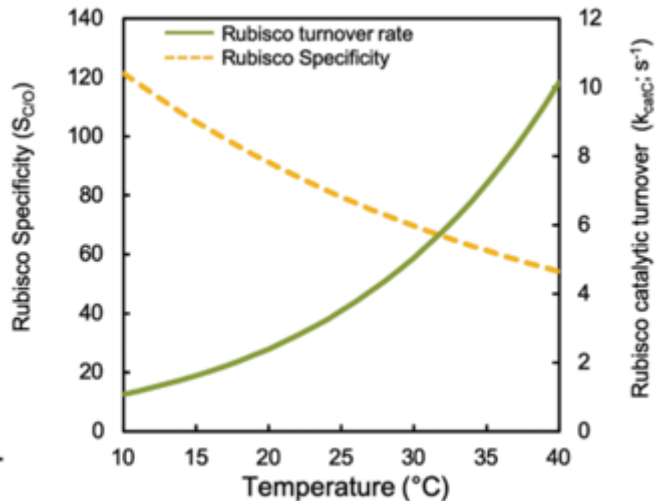


Crop plants use photosynthesis capturing energy from sunlight, water and carbon dioxide to make carbohydrates like rice and wheat.



At higher temperatures photosynthesis efficiency decreases and crop yield decreases.

The CO₂ fixing enzyme becomes less specific at high temperatures



Cattle, the “bad boys” of Agriculture greenhouse gas emissions

Beef cattle

Highest greenhouse gas production per kJ of food energy

Feeding crops to cattle is inefficient

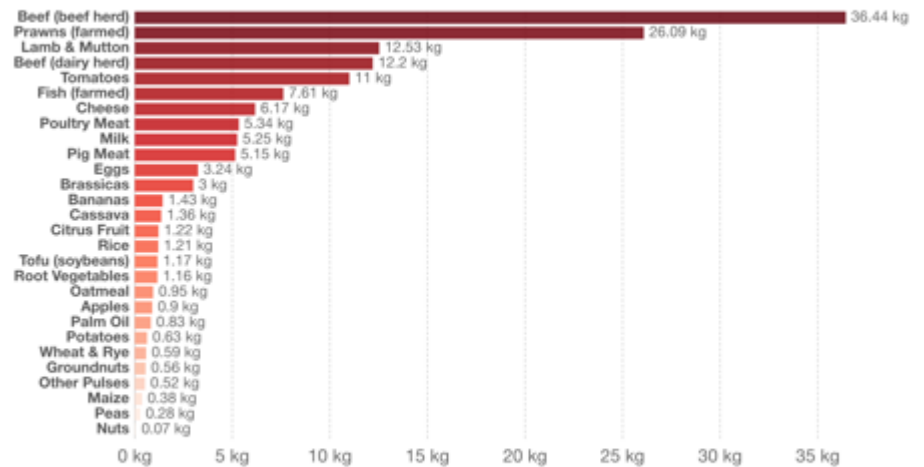
Demand for beef pasture leads to deforestation such as in the Amazon region



Greenhouse gas emissions per 1000 kilocalories

Our World in Data

Greenhouse gas emissions are measured in kilograms of carbon dioxide equivalents (kgCO₂eq) per 1000 kilocalories. This means non-CO₂ greenhouse gases are included and weighted by their relative warming impact.

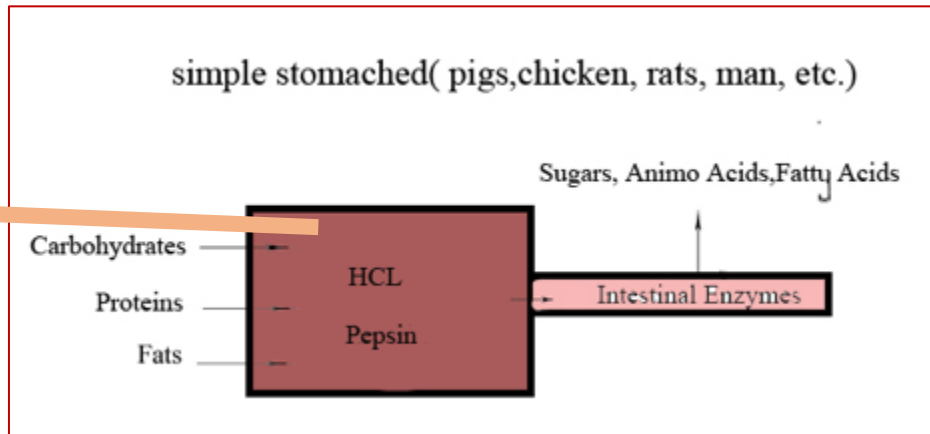
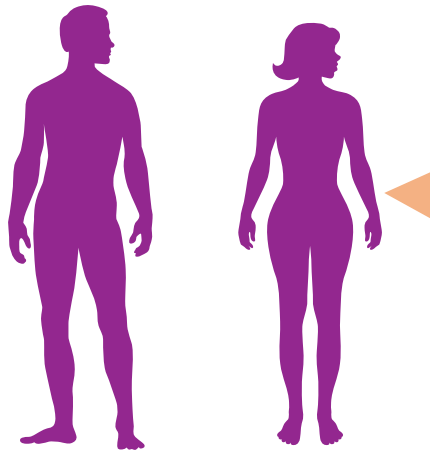


Source: Poore, J., & Nemecek, T. (2018). Additional calculations by Our World in Data.

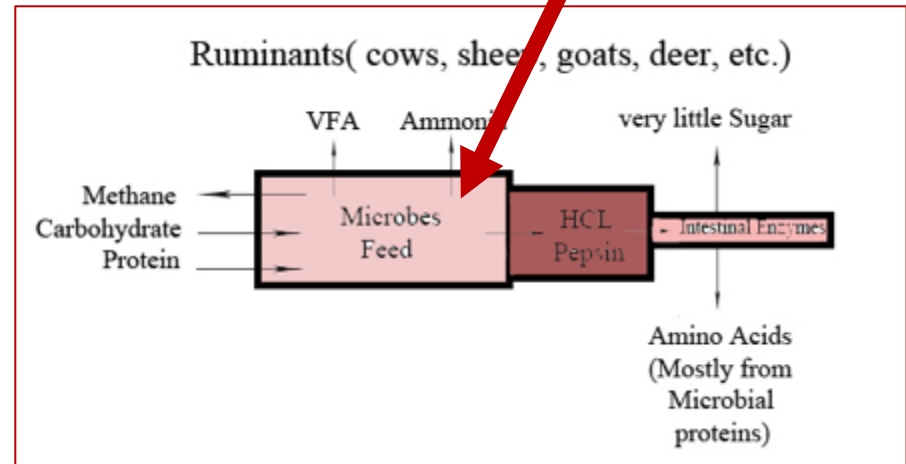
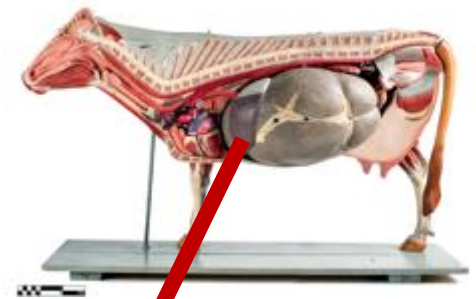
Note: Data represents the global average greenhouse gas emissions of food products based on a large meta-analysis of food production covering 38,700 commercially viable farms in 119 countries.

OurWorldInData.org/environmental-impacts-of-food • CC BY


Microbes in cattle produce methane in the Rumen



Unlike humans, cattle and other ruminants can digest the cellulose in grass. In the rumen microbes breakdown the cellulose creating useful molecules for the cow. About 3% of these microbes make 400 L of methane (CH₄) gas per day.



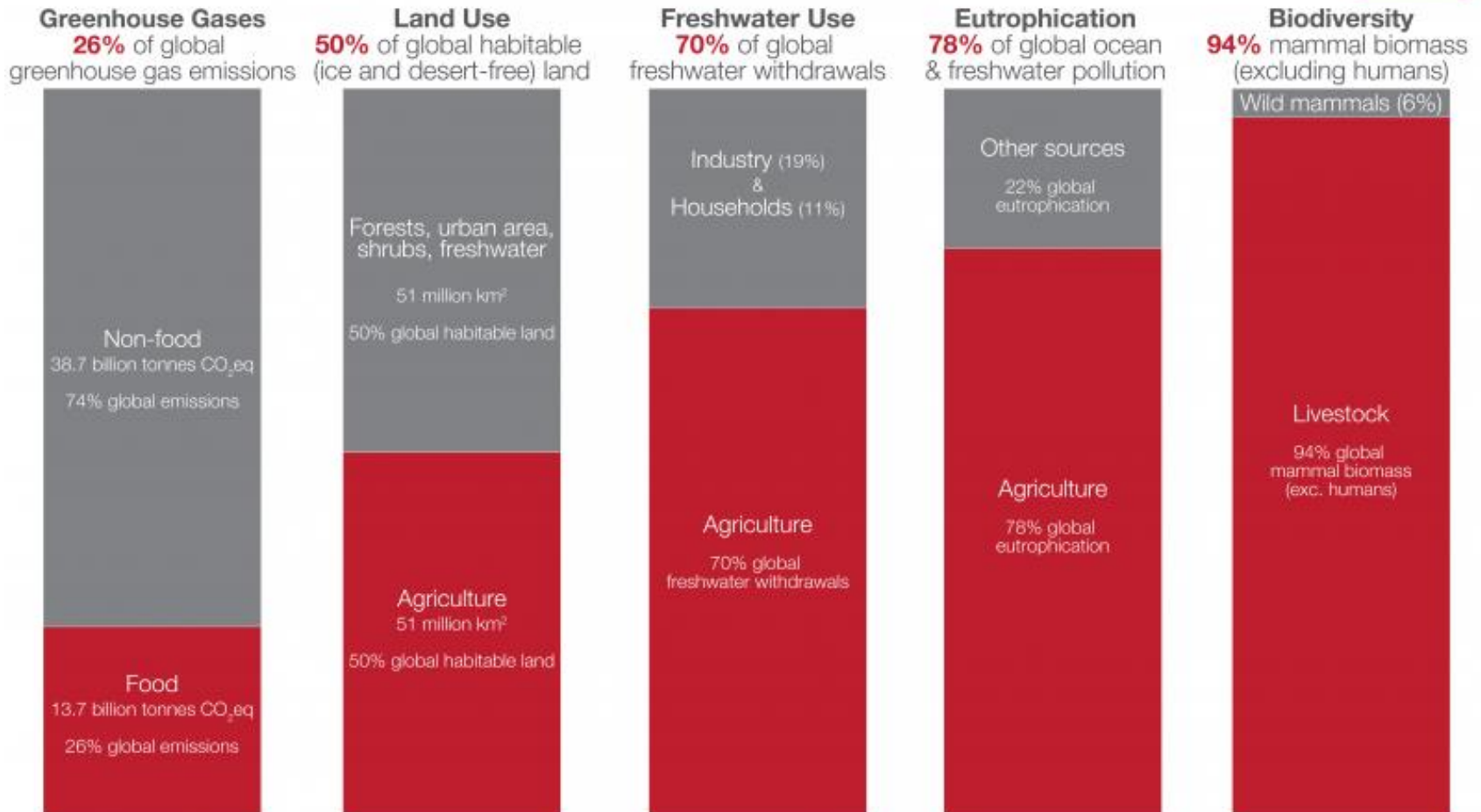
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Agriculture has an enormous impact on the world

What are the environmental impacts of food and agriculture?



More sustainable methods of agriculture are required



Many organisations and individual scientists are researching ways in which this can be achieved.

More efficient use of resources

Estimates of potential yield gain from improved irrigation

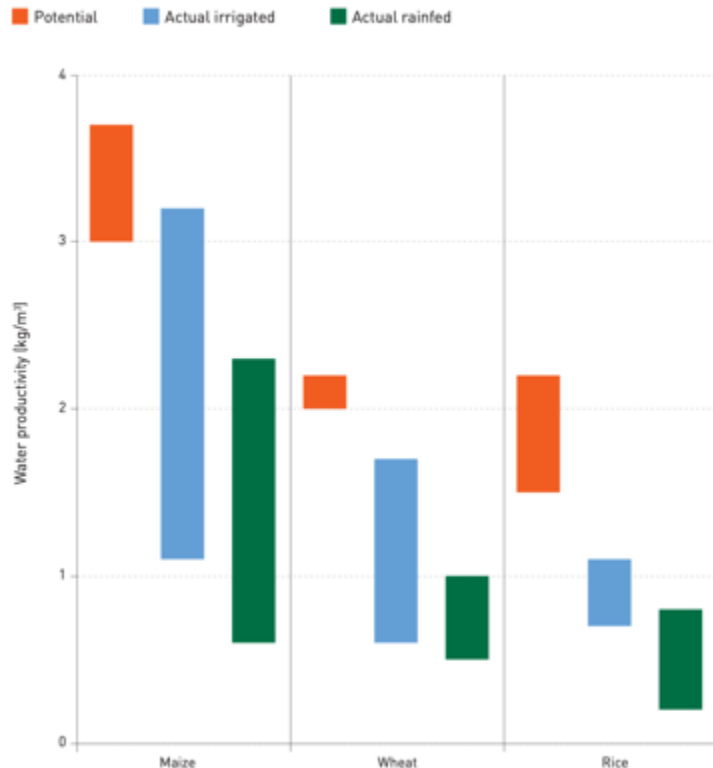
Drip irrigation maximises water useage



Strips of natural vegetation prevent water run off



FIGURE 4.1: WATER PRODUCTIVITY FOR MAIZE, WHEAT AND RICE: POTENTIAL, IRRIGATED AND RAINFED



Source: Sadras et al. (2010)

Reducing food losses and wastage

6% of global greenhouse gas emissions come from food losses and waste

Our World
in Data

Emissions from food that is never eaten accounts for 6% of total emissions



Bananas release ethylene gas which speeds up the ripening of the other bananas during transport leading to loss of up to 15% of the crop. Scientists at John Innes research institute, UK are using genetic manipulation (gm) methods to slow the rate of ethylene production

Improved crop plants adapted to increase yield in warmer conditions

Using a combination of traditional plant breeding methods and genetic modifications (gm) it may be possible to improve the characteristics of crop plants to improve resistance to high temperature and reduced water conditions

1) Increased invertase enzyme in grain to improve carbohydrate import

2) relocate carbohydrates from stem to grain

3) short erect flag leaf reduces scorching

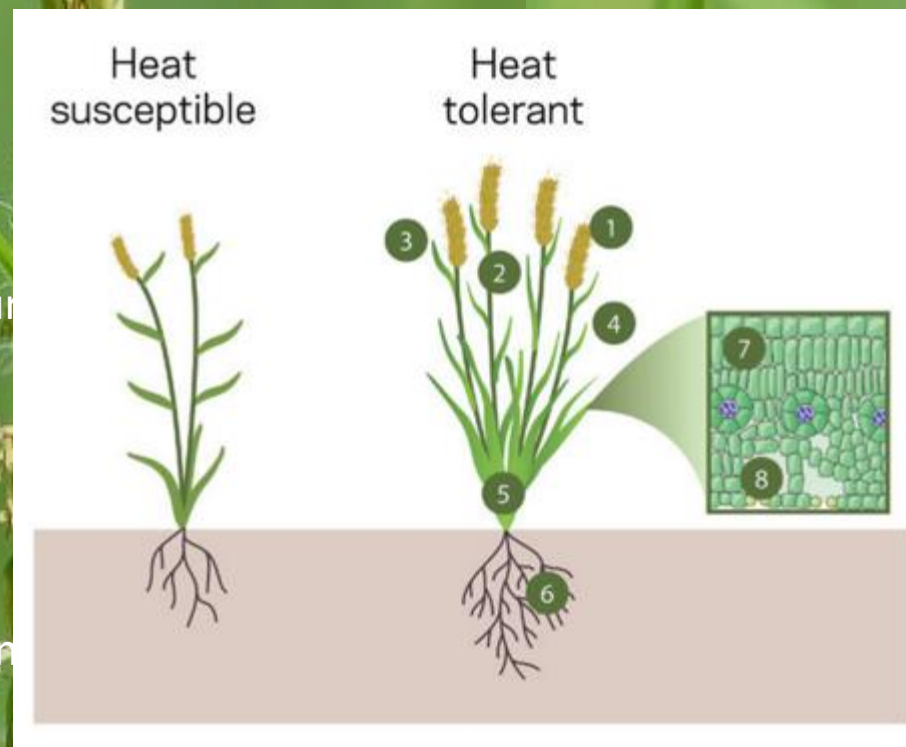
4) short erect waxy leaves reduce heat exposure

5) extra leaves to increase energy capture

6) extra roots to reach deep soil moisture

7) concentrated chlorophyll in optimum location

8) more stomata for improved CO₂ entry.



Carbon neutral cows

Planting trees in pasture land

Provide shade: boosting grass nutritional value
Cattle grow faster: 250 Kg in 2 rather than 3 years
Provide additional income from timber

EMBRAPA Brasil

250 – 350 trees per hectare
=25m³ wood per year= 5 tons
of Carbon = emission of 12
adult cows

15% reduction in methane by changing cattle feed

Caro et al (2016) *Climatic Change* 137467–480

Breeding cattle with reduced emissions

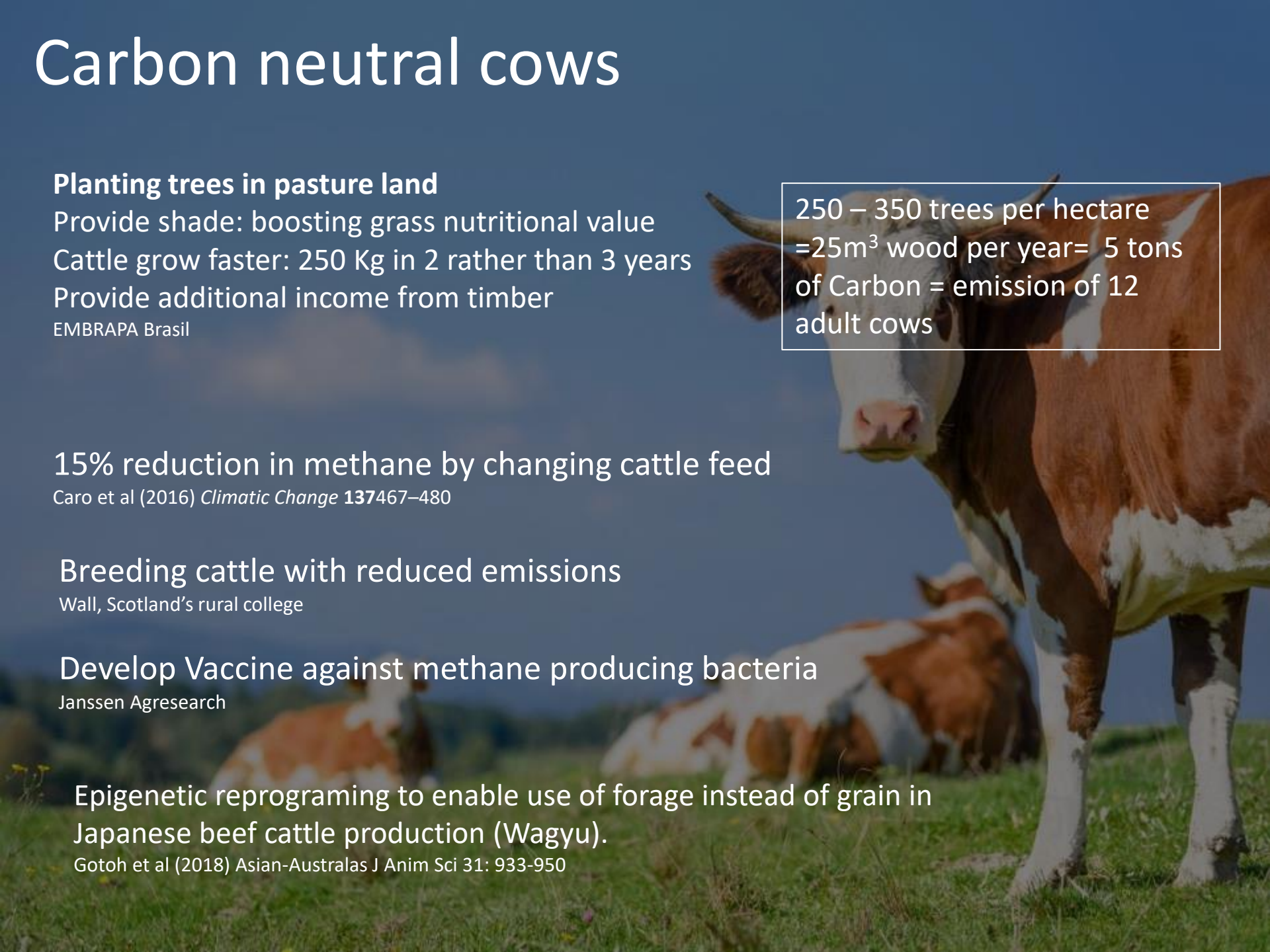
Wall, Scotland's rural college

Develop Vaccine against methane producing bacteria

Janssen Agresearch

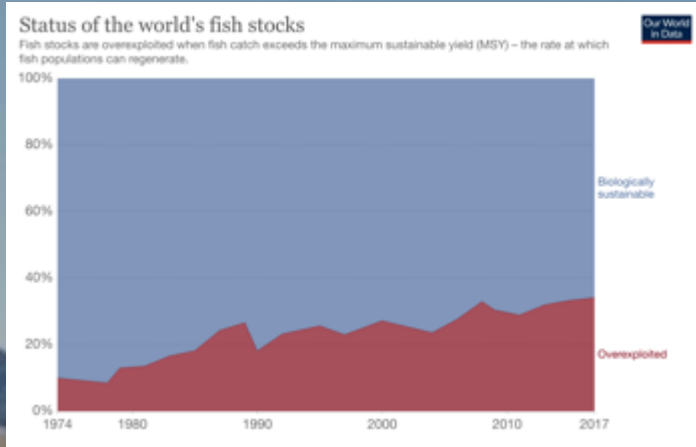
Epigenetic reprogramming to enable use of forage instead of grain in Japanese beef cattle production (Wagyu).

Gotoh et al (2018) *Asian-Australas J Anim Sci* 31: 933-950

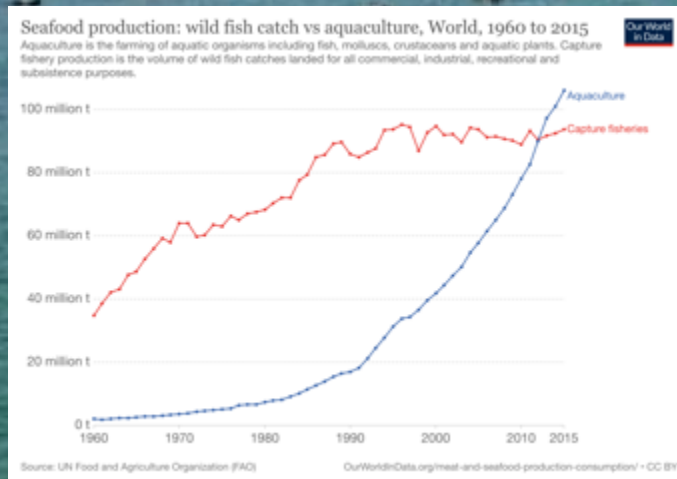


Carbon negative shellfish farming

Overfishing is threatening many wild fish stocks



Fish farming is replacing wild catch. However, it has problems in feed inputs, impacts on local wild fish



Farming of shellfish
low input
can improve water quality.
carbon negative
the shell fish capture carbon (as calcium carbonate) in their shells

Can we feed the world and still save the planet?

- 1) Increased world population will require more food
- 2) Agricultural land can only be significantly increased by destroying forests
- 3) Agriculture needs to be more productive
- 4) Agriculture is currently a major producer of greenhouse gases
- 5) Sustainable agriculture needs to increase productivity and decrease greenhouse gas emissions.

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The end

Thank you for listening