Sustainable agriculture: achieving food, energy and environmental security

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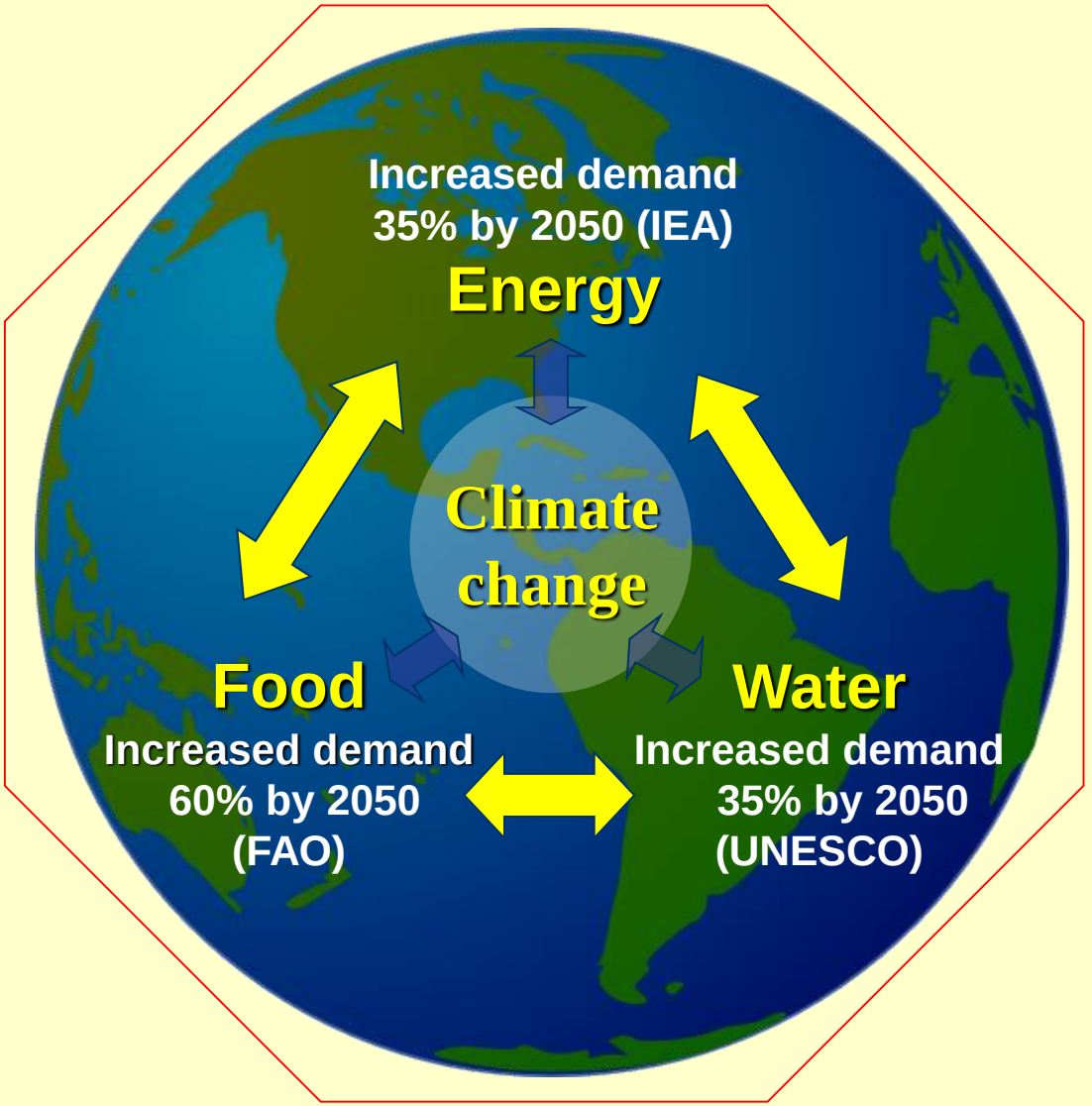
The presentation is based on the EASAC policy report on „Opportunities and challenges for research on food and nutrition security and agriculture in Europe” (2017)

EASAC: the European Academies’ Science Advisory Council

Outline

1. The global challenge
2. Food security
3. Energy security
4. Climate change
5. Intensify and/or extensify
6. Conclusions

Challenges: Food, energy and water security



climate change

http://www.nasa.gov/images/content/514175main_Yasi-MODIS-LARGE.jpg

Key questions

1. **Can we provide enough food, water and energy to supply the growing population?**
2. **Can we mitigate and adapt to climate change, and can we at the same time preserve biodiversity and ecosystems?**

Source: Own calculation based on Beddington (2009): The perfect storm

FOOD SECURITY

Food production: outlook

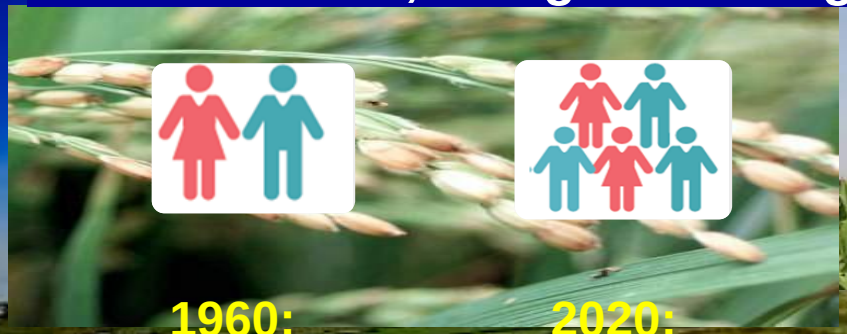
Challenge: global population growth coupled with changes in dietary habits.

Global population growth from 7.8 to 9-10 bln people by 25%.

2020-2050

Demand for food will increase by 60%.

with less water, using less energy, fertiliser and pesticides/unit production



1960: 2 persons/ha

2020: 5 persons/ha

Inefficient conversion of calories of feeds

Meat production takes 6 times more land to make the same amount of calories than cereal production.

Changing diet will have a large impact on land use in favour of feed production.

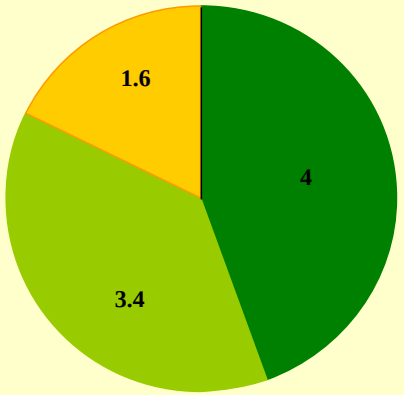
Livestock uses 66% of EU cropland.

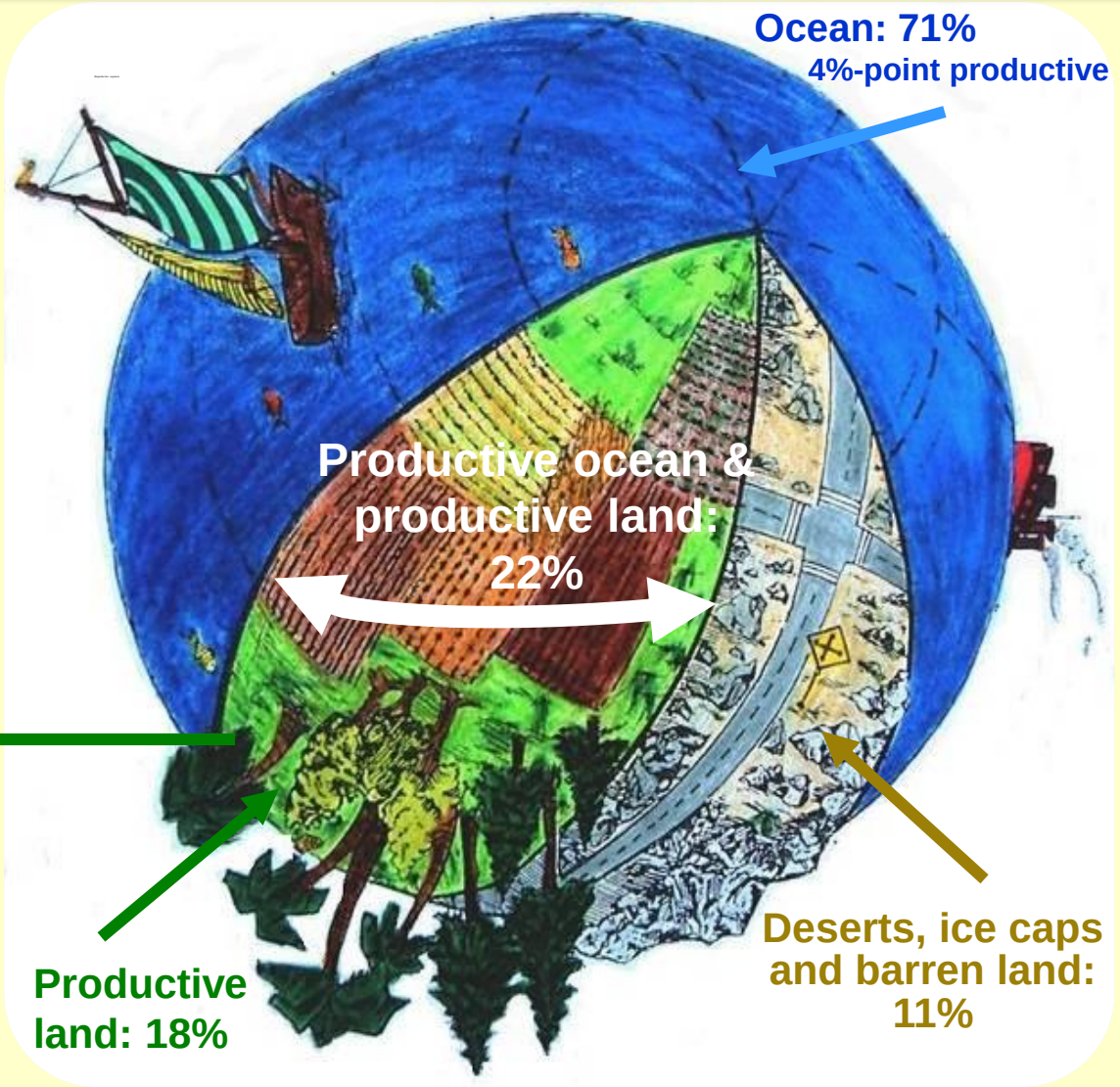
Challenge: Limited biocapacity (potential)

Surface area: 51 billion ha
Of this: 22% is productive
- 18% land + 4% ocean

Productive land area: 9 bln ha

- **4.0 bln ha forest**
- **3.4 bln ha pasture**
- **1.6 bln ha cropland**





■ forest ■ meadows/pastures ■ cropland

Productive land is limited and multifunctional.

FAO (2011): Looking ahead in world food and agriculture: perspectives to 2050. Rome.

Challenge: World population growth

China: birth control since 2016: two children/family

billion people

10 000 BC
1-10 million
Invention of agriculture

1880
1.5 billion
China:
1.3 bn in 2010

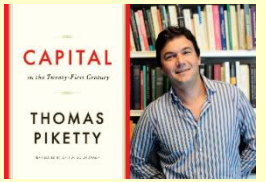
1930
2.07 billion
Hybrid maize

1960
3.02 billion
Eve of Green Revolution

2010
6.8 billion

2050
9.8 billion

2150
???



2050-2100

World	0.2%
Europe	- 0.1%
America	0.0%
Africa	1.0%
Asia	-0.2%

2040: global population will reach 9 bln people!

2019: 7.7 bln people: growth/year +1,1% (82 mln people);
2050: 9-10 bln people: 70% will live in urban areas (today 55%)

FAO (2011): Looking ahead in world food and agriculture: perspectives to 2050. Rome.

Food demand

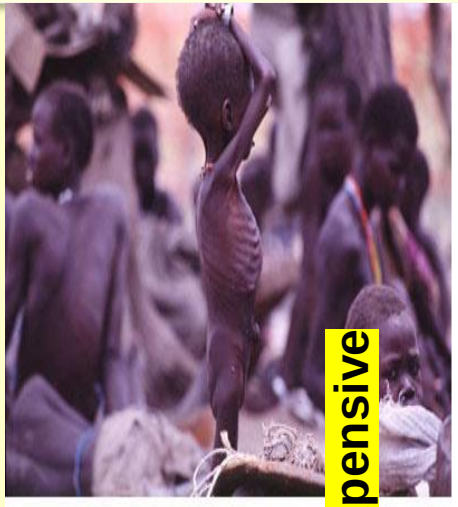
By 2050 food dietary shift will result in the consumption equivalent of 11.5 billion people at 2009 diet levels.

Changing diet will have a larger impact on land use than population growth.

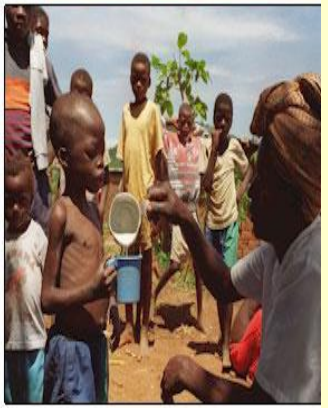
FAO (2011): Looking ahead in world food and agriculture: perspectives to 2050. Rome.

Consumption driven society versus hunger

Food is cheap



Food is expensive



The higher the income the higher the food demand!

- acces to food is the issue

Our welfare is increasing (1.3 billion people)
we suffer from that + food chain waste

… but not ours (0.8 billion people)

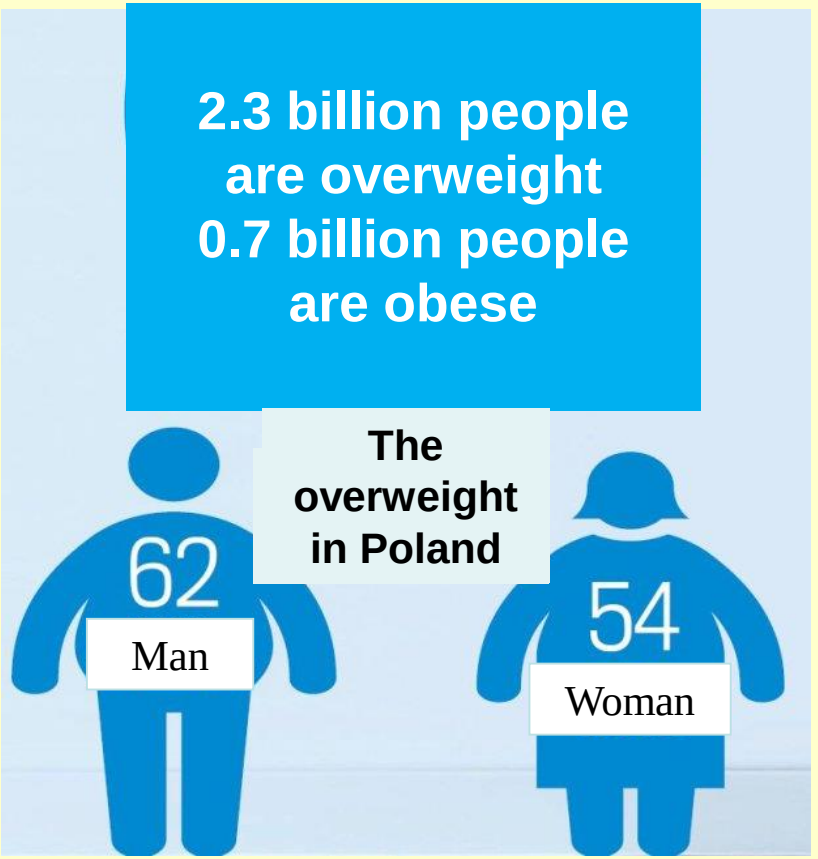
Europe is scared of a migration flow from the South to the North due to civil unrest (the multicultural model has failed in Europe).

FAO (2018)

Obesity - Epidemy?

33% of global population is overweight, out of this 30% obese

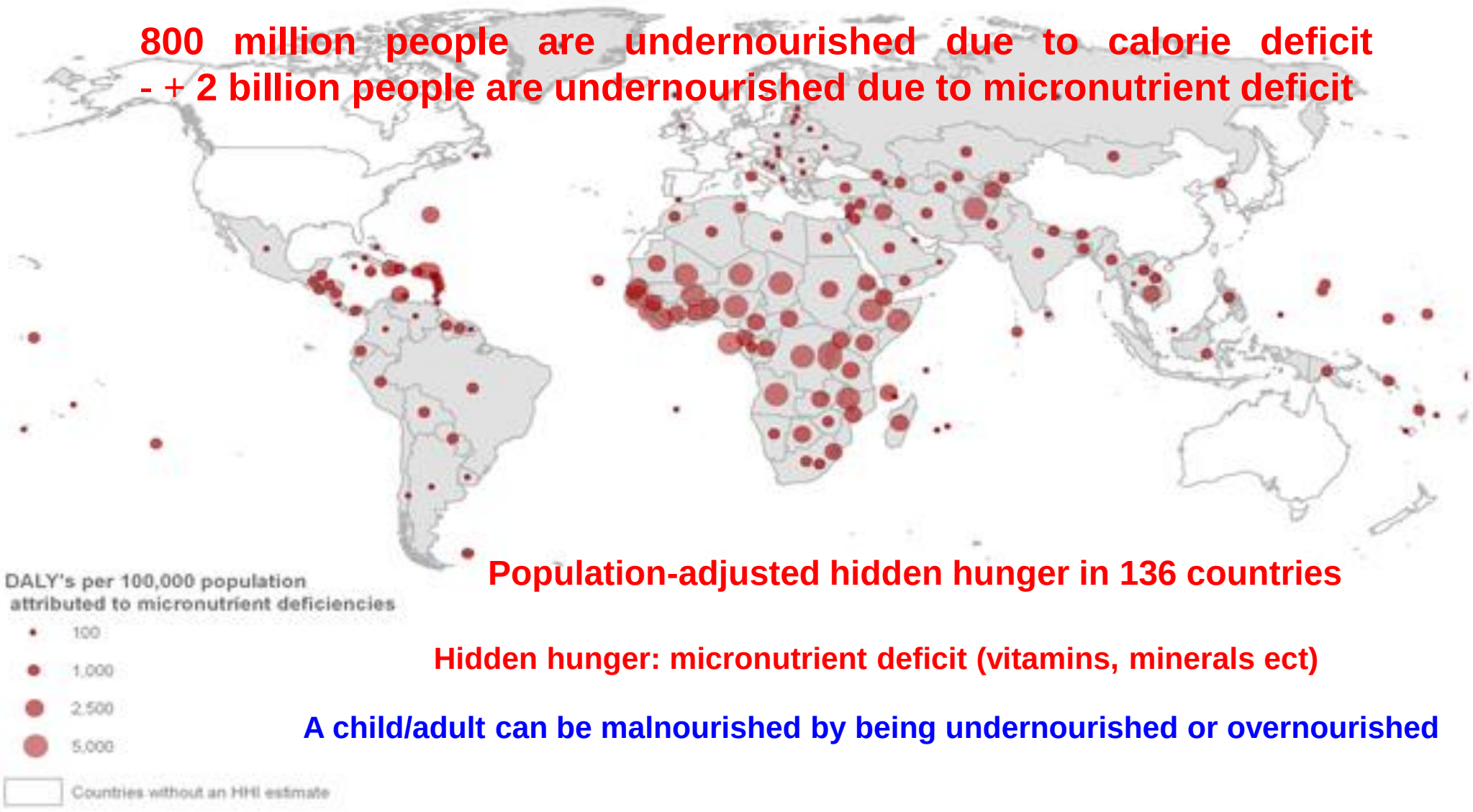
BMI: Body Mass Index: Overweight = 25-29.9; Obesity = 30 or greater



WHO: https://www.programszwajcarski.gov.pl/

The „hidden hunger” worlwide

800 million people are undernourished due to calorie deficit
- + 2 billion people are undernourished due to micronutrient deficit



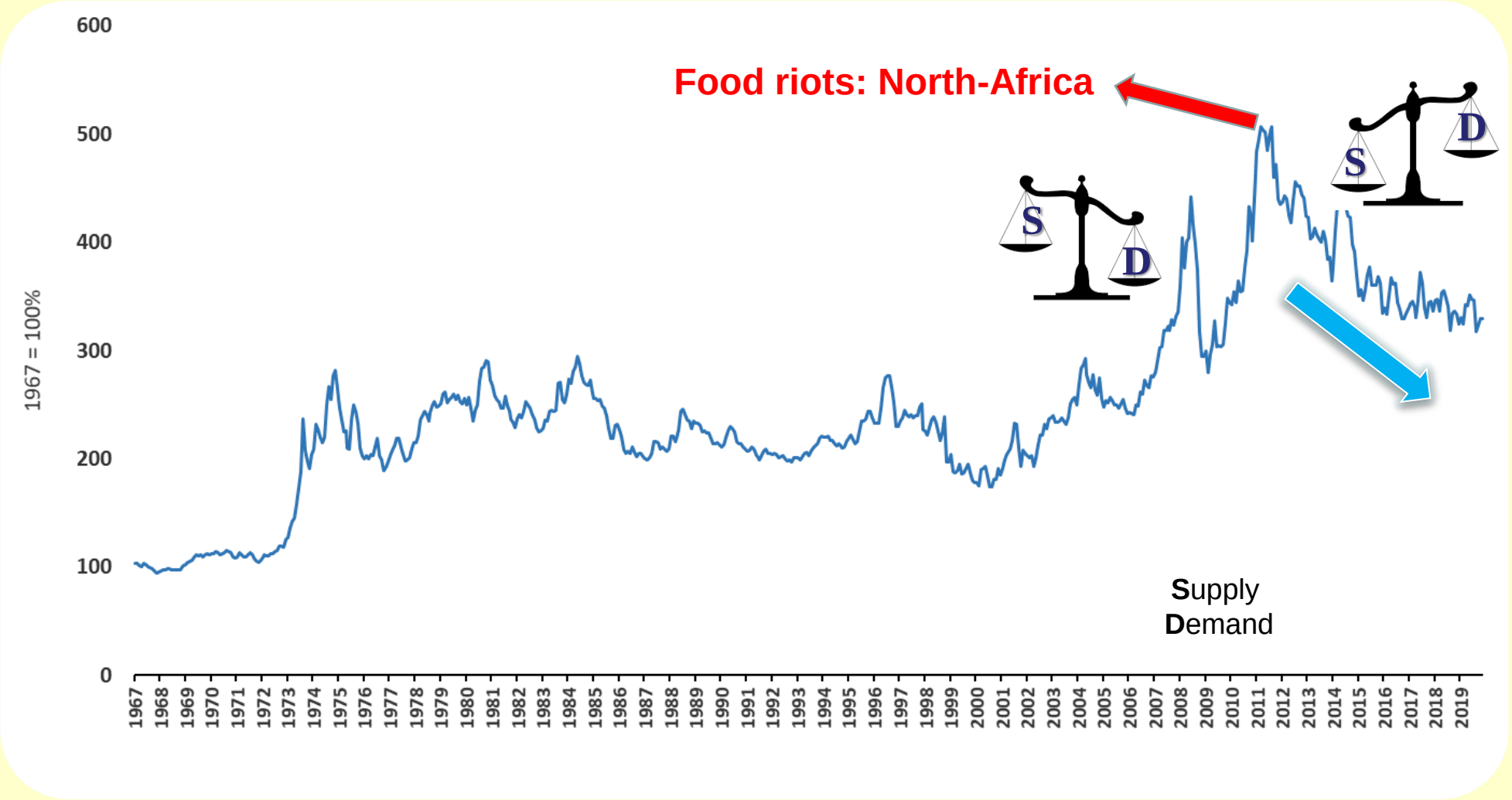
Population-adjusted hidden hunger in 136 countries

Hidden hunger: micronutrient deficit (vitamins, minerals ect)

A child/adult can be malnourished by being undernourished or overnourished

Muthayya S, Rah JH, Sugimoto JD, Roos FF, Kraemer K, et al. (2013) The Global Hidden Hunger Indices and Maps: An Advocacy Tool for Action. PLoS ONE 8(6): e67860. doi:10.1371/journal.pone.0067860

Thomson Reuters/Jefferies CRB foodstuffs sub-index (January 1967 to November 2019)

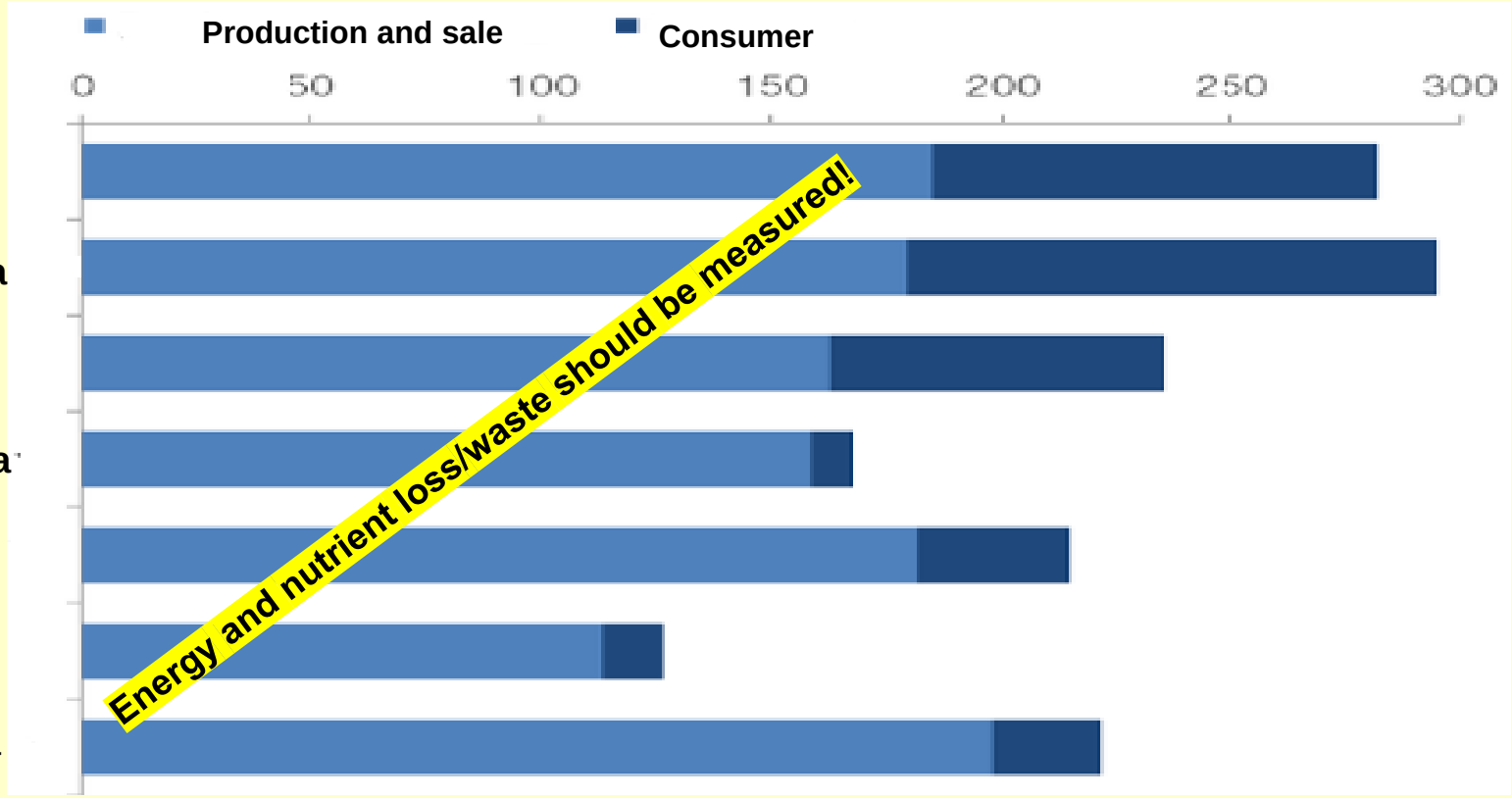


Commodities: wheat, sugar, steers, hogs, cocoa, maize, soybean oil, butter and lard

Source: Barchart

Food loss and food waste worldwide

Evidence-based data of food waste and loss is weak.
NGOs quote (1.2-2.0 billion t /year)

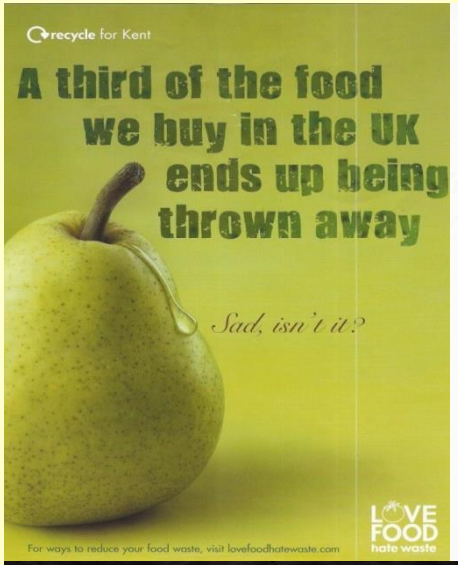


food loss: depends on technology **food waste**: depends on consumer's behavior

In developing regions food loss and food waste is lower than in developed regions.

Source: World Economic Forum. (2016). Which countries waste the most food?

Food waste (NGOs quote)



Challenge: Food chain losses (= energy + water losses)

The food sector accounts for 30% of global energy use and the energy embedded in global annual food losses is 38% of the final energy consumed by the whole food chain.

Producer

- **Field losses** — Pests and diseases
- **Pre-processing** — Broken grains, excessive dehulling
- **Transport** — Spillage, leakage
- **Storage** — Insects, rodents, bacteria
- **Processing & Packaging** — Excessive peeling, trimming, inefficiency
- **Marketing** — In retailing
- **Plate waste** — By consumers and retailers

Consumer

20-40%

10-15% in quantity

25-50% in value (quality)

5-30% developed

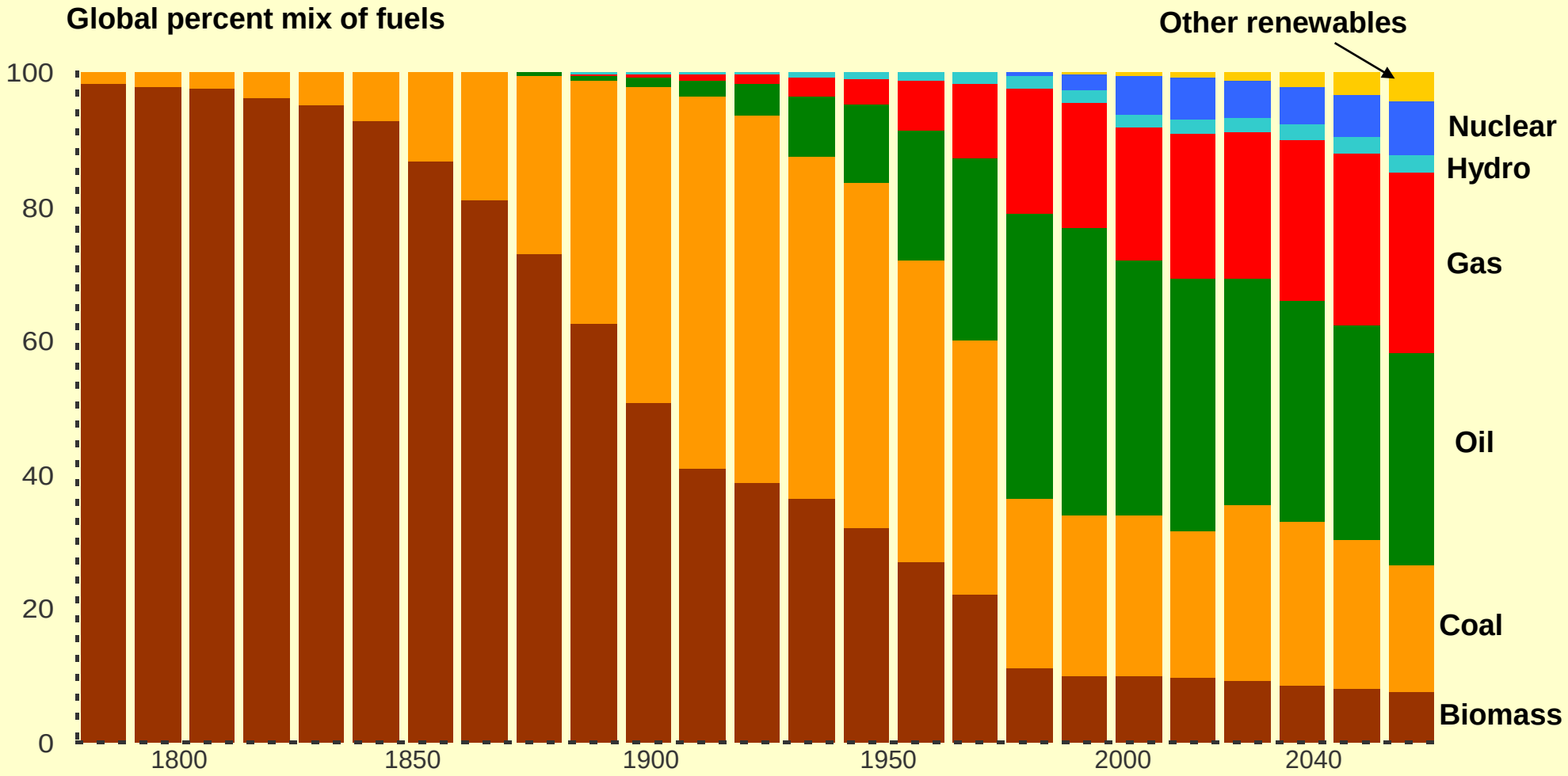
2-20% developing

For cereals losses reach 60-70%!

IWMI (2007): Water for food, water for life: A comprehensive assessment of water management in agriculture, International Water Management Institute, London.

ENERGY SECURITY

Global fuel consumption between 1800 and 2040



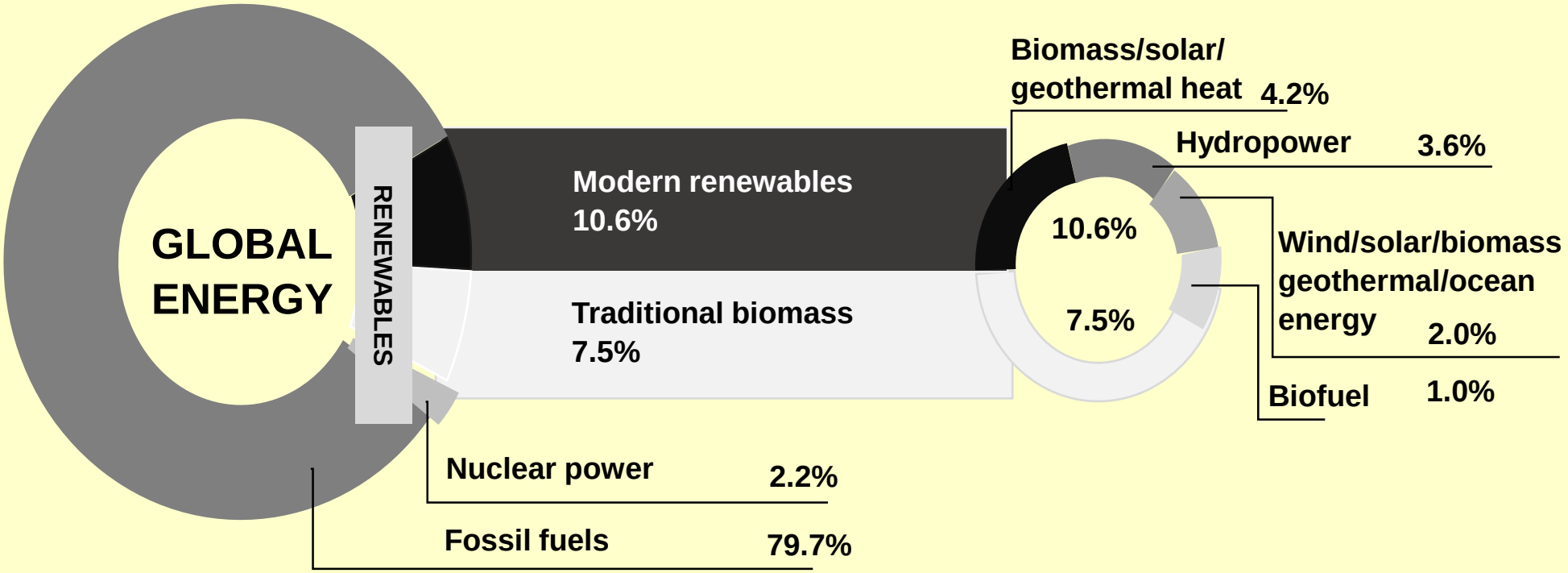
Until the late 1700s energy consumption was based on biomass energy.

After the industrial revolution coal reached a 50% share in energy use by the beginning of the 20th century.

With the introduction of the internal combustion engine (1900) demand for fossil fuels increased fast.

Source: own construction based on Smil (2000) and IEA (2018)

Renewable energy share of global final energy consumption (2017)



In the global final energy consumption the share of fossil fuels is 79.7%, the share of renewable energy 18.1% and the share of nuclear power 2.2%.

The relative contribution from renewables has increased from 13% to 18% in ther past 40 years:

- the share of traditional biomass has decreased and use of modern biomass has grown

Source: IEA (2019); REN21 (2019)

Biofuels: challenge in the traffic sector

- The transport sector has a 33% share in total final energy consumption:
  - 96% of vehicles are dependent on petroleum
  - 3% on biofuels
  - 1% on electricity (0.3% on renewable electricity)

- >50% of oil is used for transport fuel.

- The passenger vehicle fleet will increase from 1.3 to 2.0 billion by 2035.

- Liquid biofuels for transport are generating the most attention, although only a small fraction of biomass is used globally for biofuels production:
  - accounts for less than 10% of total biomass-based bioenergy.

Source: IEA (2019)

Food for biofuels: decreasing competition for crops

- **The proportion of global cropland used for biofuels is 2%, however, for some crops (e.g. maize, oilseeds, sugar cane, vegetable oil) biofuel demand accounts for a significant share of total demand.**

- **20% of global sugarcane and 12% of global vegetable oil and 10% of global coarse grains production is used to produce ethanol and biodiesel.**

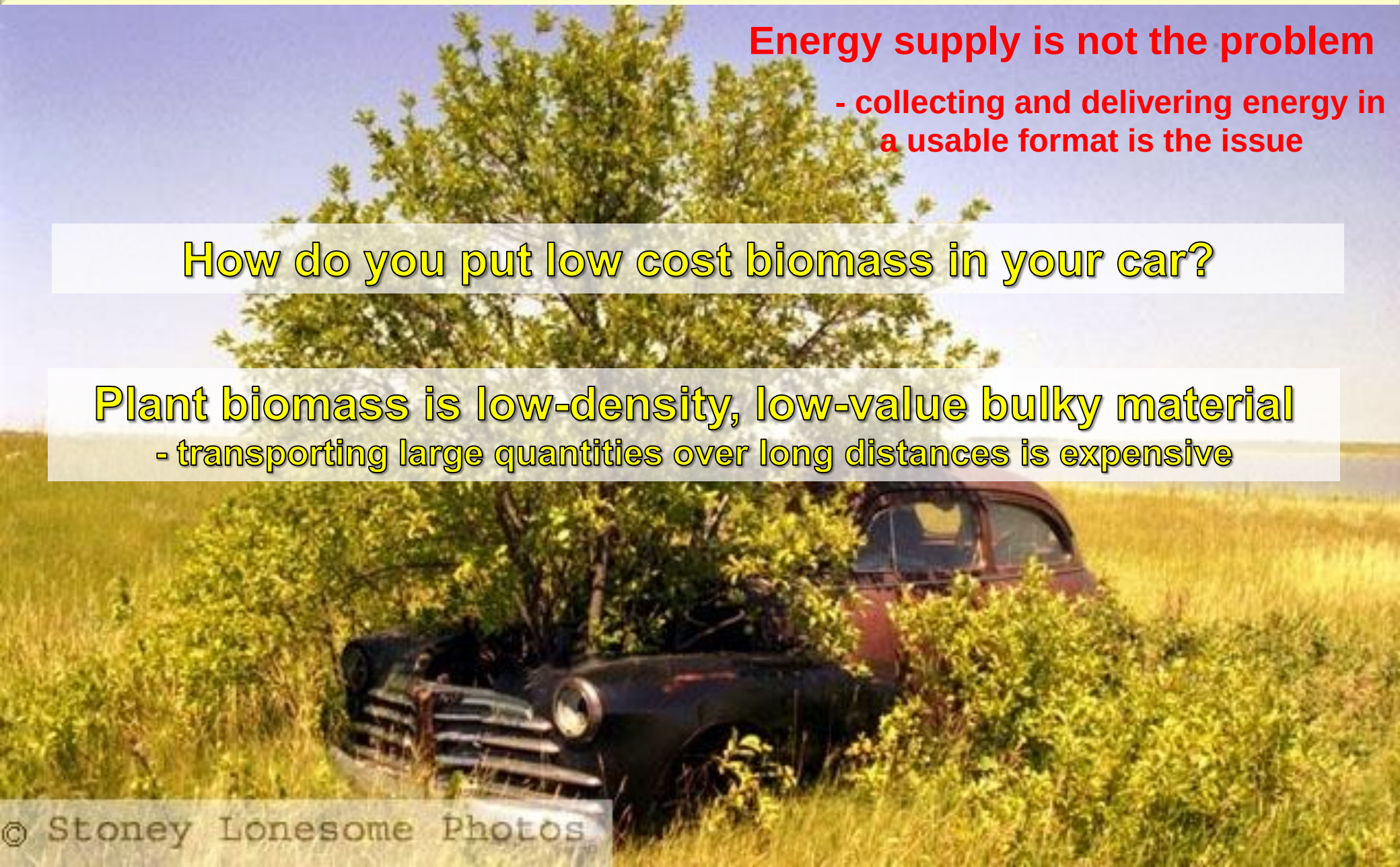
- **The EU and US have introduced caps on food-based biofuels.**

- **By adding co-products substituted for grains and oilseeds the land required for cultivation of feedstocks declines to 1.5% of the global crop area.**

  - biofuel represents a very small percentage of overall changes in land use.

- **The development of biofuels production based on non-agricultural feedstock progress slowly.**

Next generation biofuels: reduce GHGs further



ENVIRONMENTAL SECURITY

Global CO_2 emissions

70% of food imports in the EU comes from developing coutries vulnerable to climate change

Global energy demand increases by 35% in 2050

2018: CO_2 emissions reached 37 billion tonnes (CO_2 concentration 405 ppm)

89% of CO_2 emissions are energy-related (of this: transport 23%)

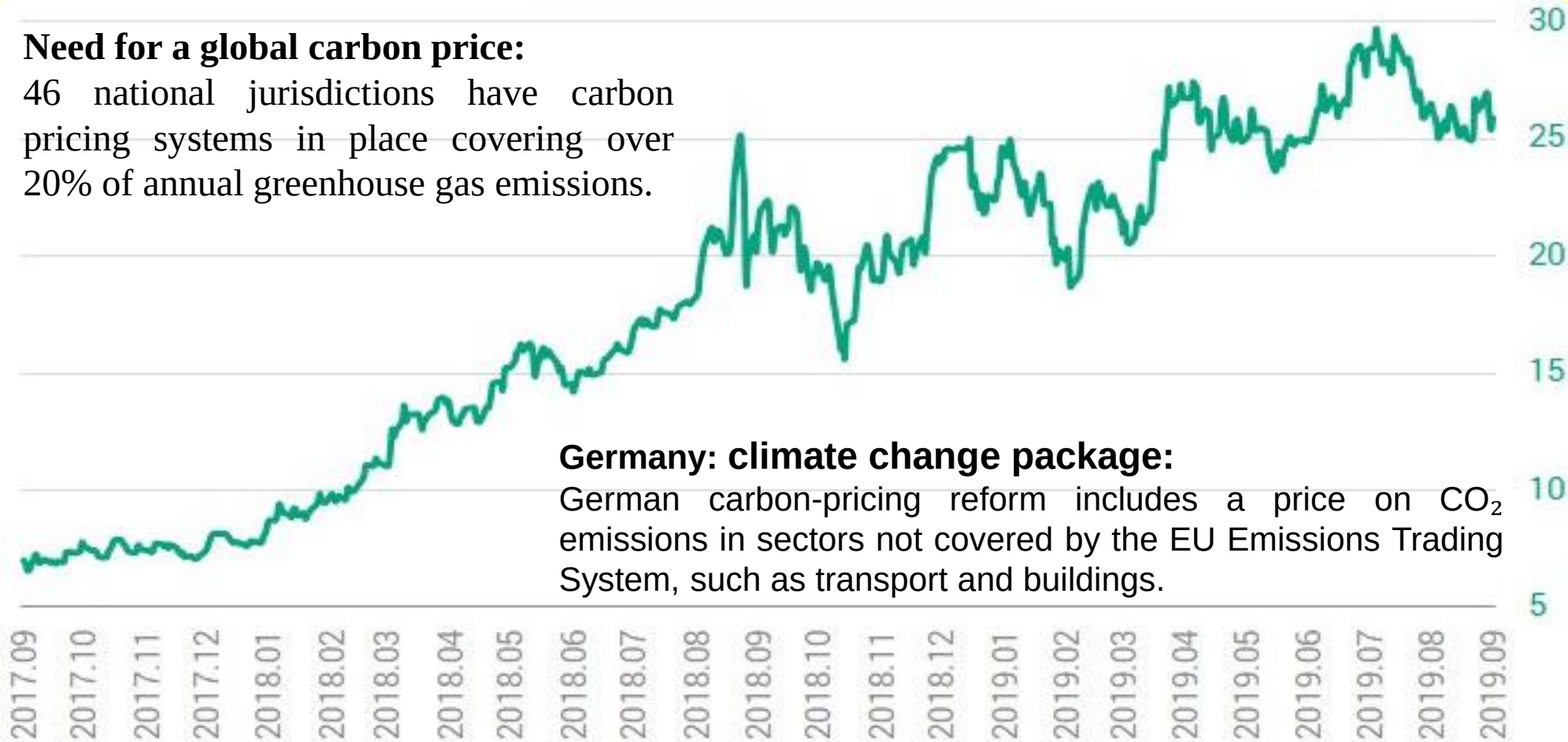
The passenger vehicle fleet increases from 1.3 to 2.0 billion by 2035

Source: REN21 (2019); IEA (2018)

Price of CO_2 European Emission Allowances (EUR/t)

EU Emissions Trading System

Need for a global carbon price:
46 national jurisdictions have carbon pricing systems in place covering over 20% of annual greenhouse gas emissions.



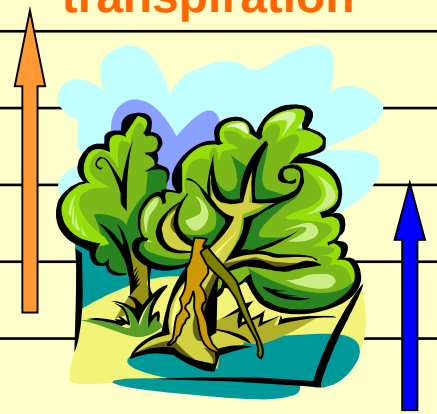
Germany: climate change package:
German carbon-pricing reform includes a price on CO_2 emissions in sectors not covered by the EU Emissions Trading System, such as transport and buildings.

Forrás: Thomson Reuters (2019)

Global drying: water crisis

Water 'bubble' is unsustainable and fragile: 7.7 billion people today have to share the same quantity as the 300 million global inhabitants of Roman times.

Water use	Litres of water
Drinking water	2-5 litres/person/day
Household use	20-500 litres/person/day
Wheat	500-4,000 litres/kilo
Meat	5,000-15,000 litres/kilo
Biofuel	1,000-3,500 litres/litre
Cotton t-shirt	2,000-3,000 litres
Agriculture	3 000 litres/person/day litre/calorie



- About 78% of water for food comes directly from rain.
- An increasing part is met by irrigation.

Source: IWMI (2007)


A quarter of the world's population lives in closed or closing basins!
Closed basins – build until there is no more water left
2 bln people lack access to safely managed drinking water
Water scarcity: "water is the new oil"
- Waterexchange.com.au (Australia)!
No water left for more development
Yellow River, Colorado, Amu/Syr Darya, Murray- Darling, Egypt's Nile, Jordan..
Groundwater overdraft (India): 60% of farmers are dependent on ground water irrigation

Warning signal: climate change/soil damage

- **We are all responsible for climate change**
  - How much we are responsible depends on our country of residence, lifestyle and consumption patterns, with the rich being the most responsible?

- **Soil damage: 25% of agricultural land is seriously degraded.**

- **Biological productivity is limited by extremes, not by averages.**

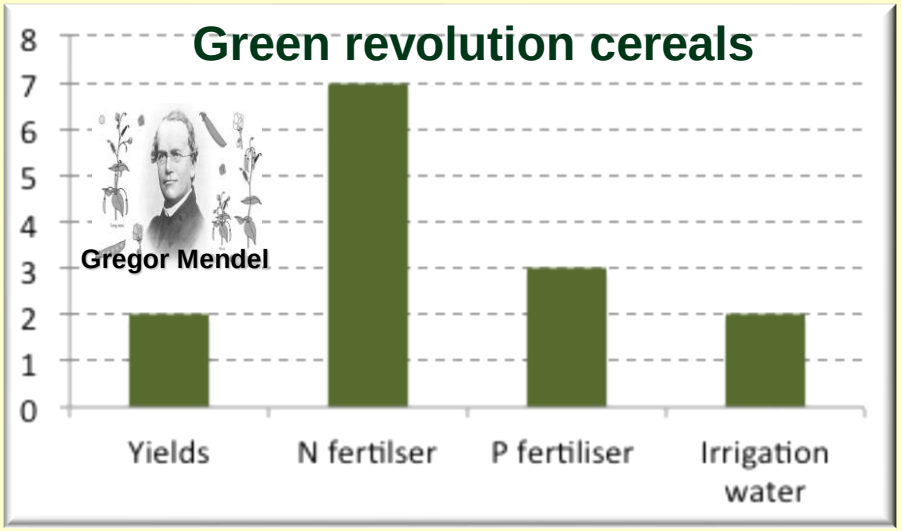
FAO (2011): State of the world's land and water resources for food and agriculture. Summary Report. FAO. Rome

Green revolution versus sustainable intensification

- **The keys to the Green Revolution were: improved seeds + inputs + water**

Breeding for more yield while increasing N and water dependence

- Breeding of cereals
- Irrigation management
- Fertilisers, mainly nitrogen



- **What are the keys to sustainable intensification**
  - Plant breeding (shorter seasons, less water use, GM etc.)
  - Improving N efficiency
  - Decoupling N to yield dependence

What is sustainable intensification?

How do we get there?

Increase production on current land area while sustaining natural resources:

- **reduce inputs + water use + waste**
- **increase crop yields + resilience to climate variations**

Sustainable intensification = nutrient management

1. Extensification – agricultural environmental programme

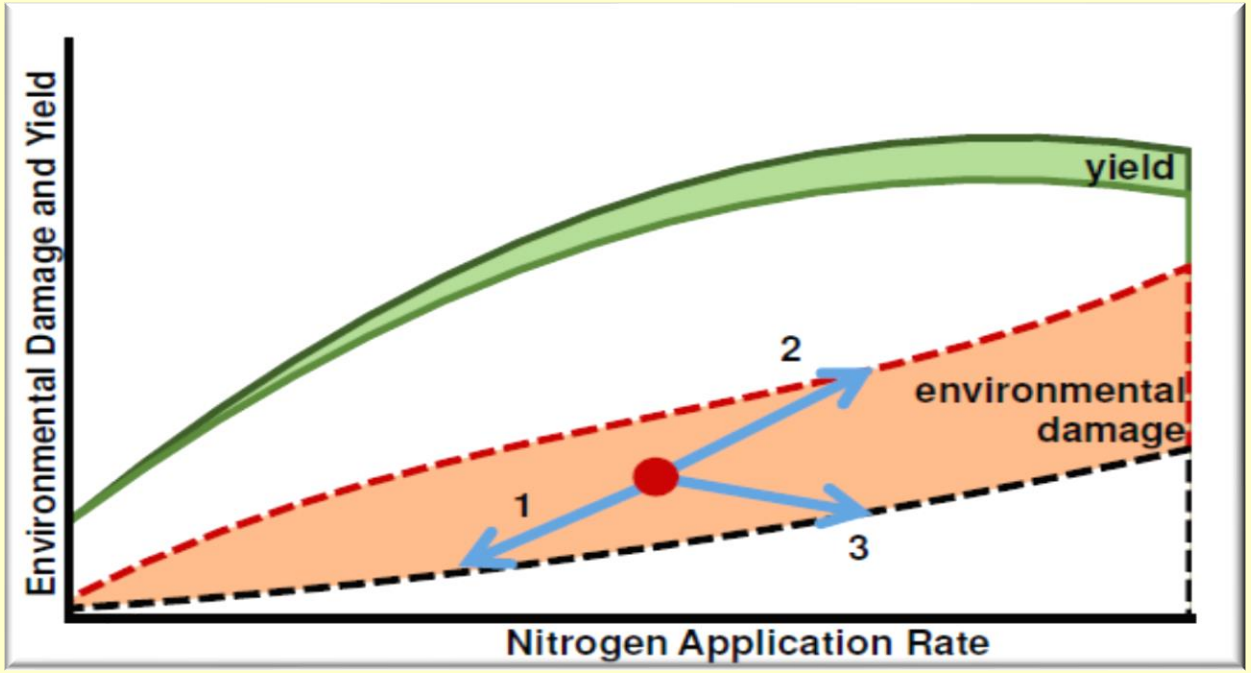
- Decrease in environmental damage by reducing N fertiliser, but also decrease in yield.

2 . Intensification

- Luxury supply with N: increase in yield but strong increase in environmental damage.

3. Sustainable intensification

- Very efficient use of N: increase in yield and decrease in environmental damage.



Heißenhuber and Peter Schießl (2014): Sustainable Intensification- Nutrient Management Presentation. Technische Universität München-Weihenstephan. Freising-Weihenstephan

Conclusions

- **Land, energy and water availability are limited.**
- **Existing agricultural areas will be lost to other uses (bioenergy).**
- **Soil degradation will continue for many areas.**
- **Changing climate will add additional production stress.**
- **The Green Revolution demonstrated promises and constraints.**
- **Sustainable intensification is an opportunity:**

  - technology and economics (profitability) will be very important.

BE SPECIFIC NOT GENERAL!