Europe's agri-food system and its consequences on environment and human health

www.jrc.ec.europa.eu

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Serving society
Stimulating innovation
Supporting legislation

Joint Research Centre

Outline

- Environmental impact of food production
- Health impact
- Sustainable Food and Nutrition Security
- Food systems assessment
- Action needed
  - Farm level
  - Supply chain
  - Consumer
- Conclusions

The WAGES of Nitrogen

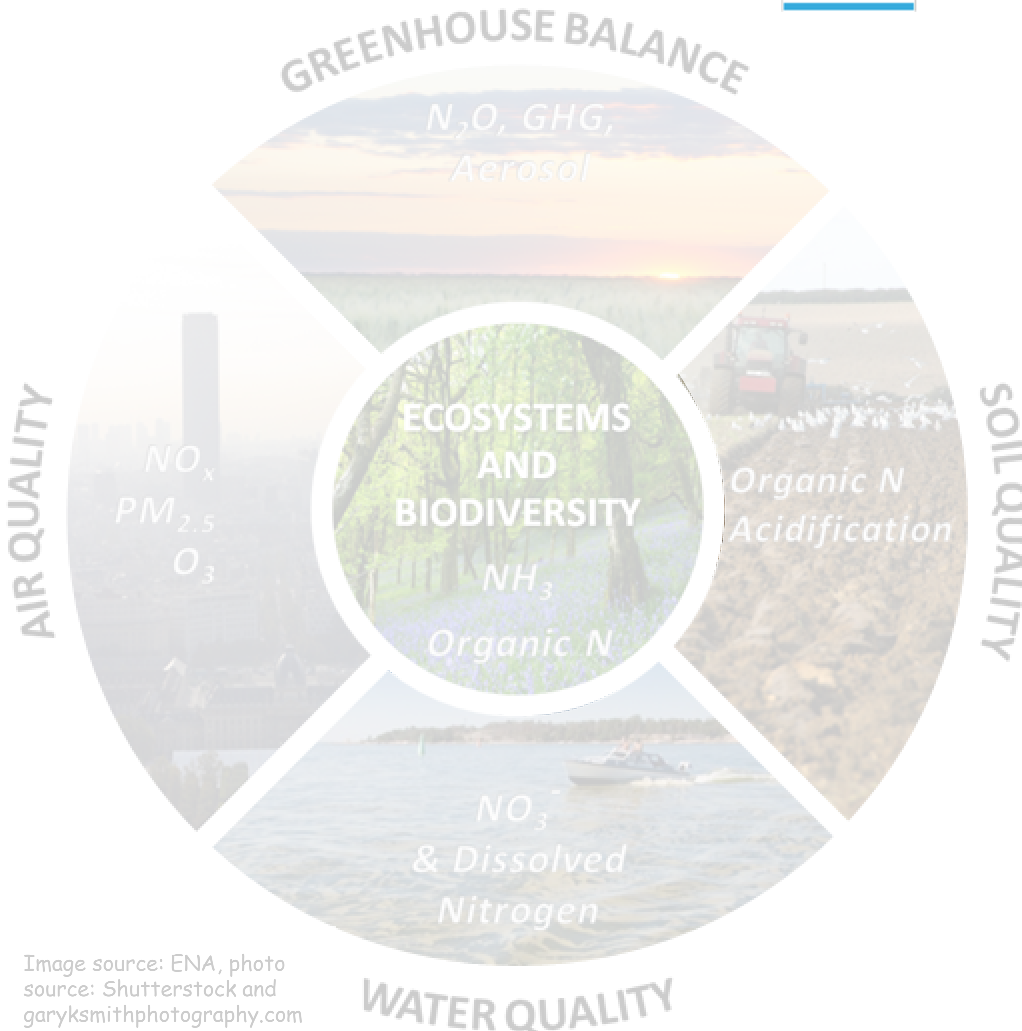

Image source: ENA, photo source: Shutterstock and garyksmithphotography.com

Water quality

Coastal eutrophication, nitrate in groundwater, …

Air quality

Health effects, Cultural heritage, Crop yields, …

Greenhouse gas balance:

Carbon losses/ sequestration, N2O and CH4 emissions, indirect effects, …

Soil quality:

Erosion, soil compaction, acidification, …

Ecosystems and biodiversity:

Land use, soil eutrophication, …

European Nitrogen Assessment, Sutton et al., 2011

CAPRI-Life Cycle Assessment: Agricultural budget and indirect flows and share caused by livestock production, feed, and feed imports

European Commission

	Total Agricultural LCA flow within EU27 territory	Total EU27 budget flow	Share agriculture (excl. feed imports)	**Share livestock (vs agriculture, full LCA data)**
Air pollution - NH3 emissions [Tg N yr-1]	2.6	2.7	94%	**82%**
Air pollution - NOx emissions [Tg N yr-1]	0.3	2.6	13%	**66%**
Air pollution - NOx + NH3 emissions [Tg N yr-1]	2.9	5.3	55%	**80%**
Soil acidification - SO2 [Teq yr-1]	0.021	0.35	6%	**67%**
Soil acidification [Teq yr-1]	0.18	0.56	32%	**79%**
GHG emissions [Tg CO2eq yr-1]	651	4889	13%	**81%**
GHG emissions - Carbon sequestration [Tg CO2eq yr-1]	-93	-170.5	55%	**80%**
GHG emissions - GHG + Carbon seq. [Tg CO2eq yr-1]	558	4718.4	12%	**81%**
Water pollution - N [Tg N yr-1]	5.4	9.1	59%	**73%**
Water pollution - DIP [Tg P yr-1]	0.025	0.25	10%	**73%**
Land Use [Mio km2]	1.8	4.2	42%	**69%**
Loss of biodiversity [relative MSA]	-34%	-65%	51%	**76%**

Leip, A. et al., 2015. Impacts of European livestock production: nitrogen, sulphur, phosphorus and greenhouse gas emissions, land-use, water eutrophication and biodiversity. Environ. Res. Lett. 10, 115004.

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Air pollution - NO_x emis[illegible]	[illegible]	[illegible]	[illegible]	**66%**
Air pollution - NO_x + NH[illegible] [Tg N yr-1]	[illegible]	[illegible]	[illegible]	**80%**
Soil acidification - SO_2 [[illegible]	[illegible]	[illegible]	[illegible]	**67%**
Soil acidification [Teq yr[illegible]	[illegible]	[illegible]	[illegible]	**79%**
GHG emissions [Tg CO2[illegible]	[illegible]	[illegible]	[illegible]	**81%**
GHG emissions - Carbon[illegible] [Tg CO2eq yr-1]	[illegible]	[illegible]	[illegible]	**80%**
GHG emissions - GHG + [illegible] [Tg CO2eq yr-1]	[illegible]	[illegible]	[illegible]	**81%**
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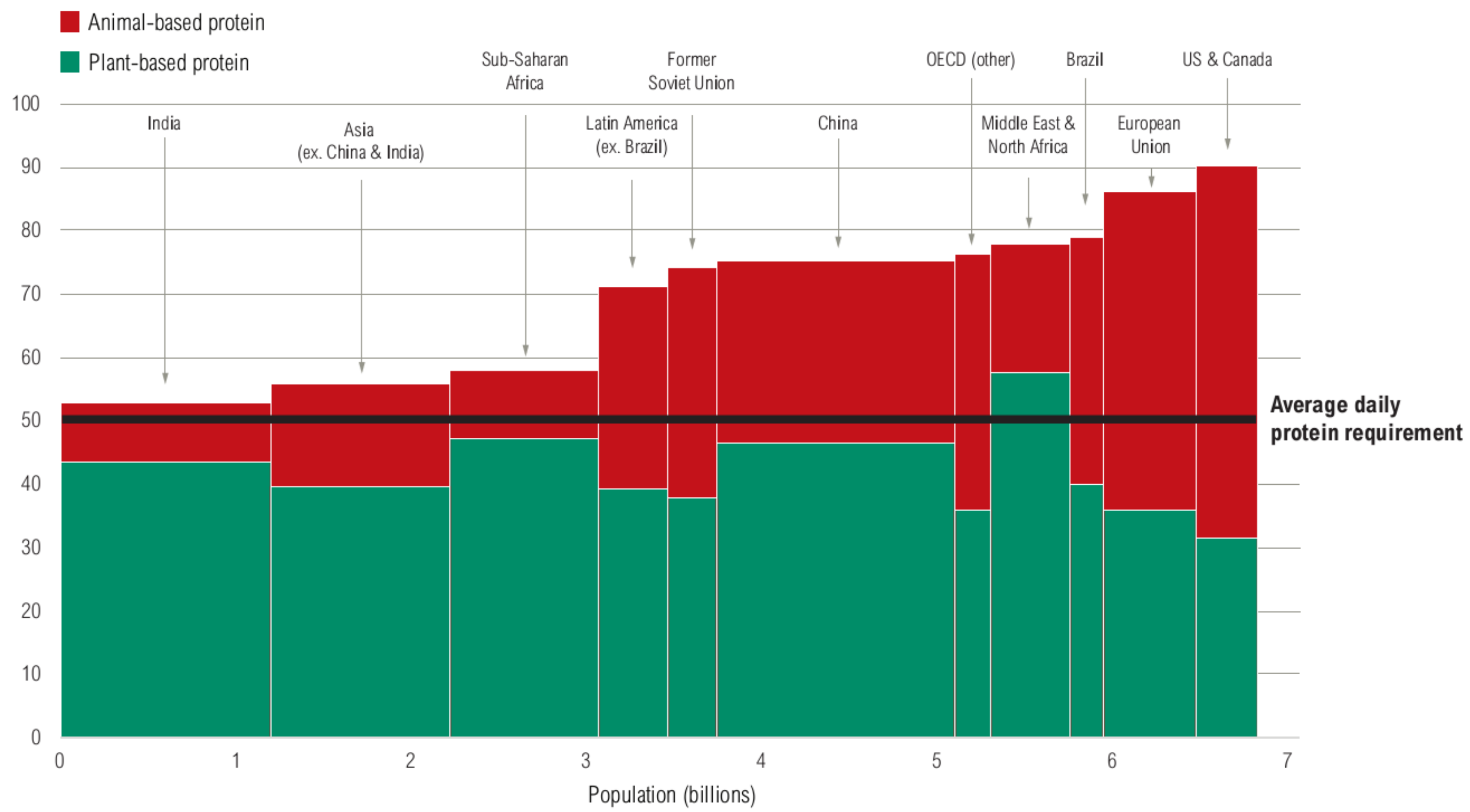
Leip, A. et al., 2015. Impacts of European livestock production: nitrogen, sulphur, phosphorus and greenhouse gas emissions, land-use, water eutrophication and biodiversity. Environ. Res. Lett. 10, 115004.

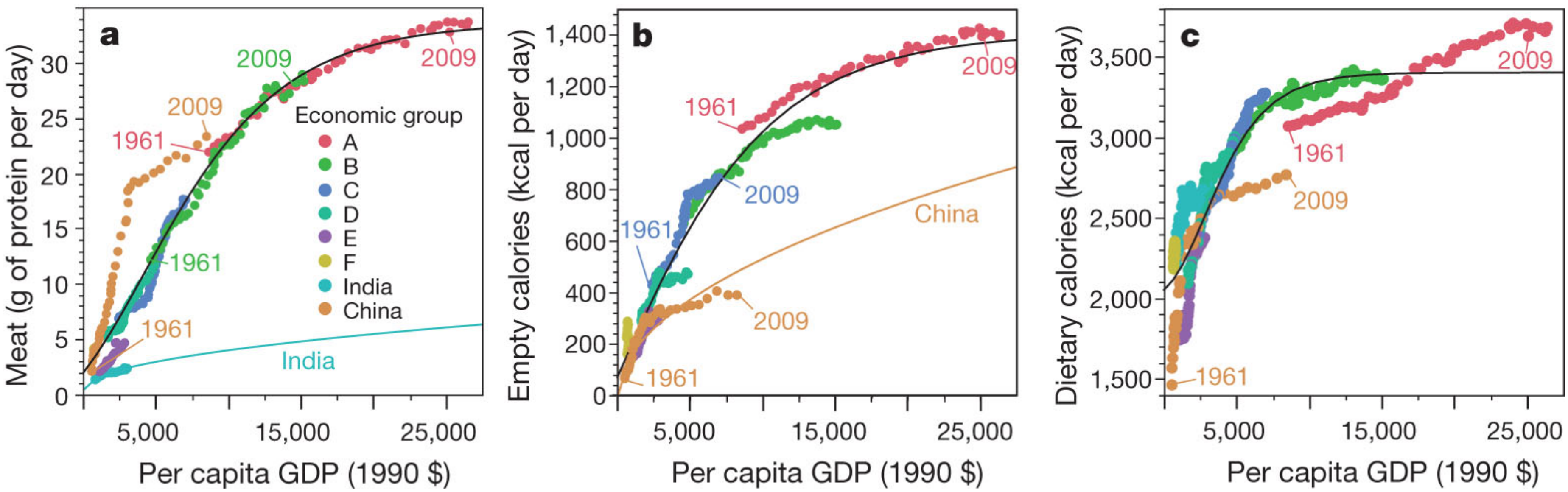
Protein Consumption Exceeds Average Estimated Daily Requirements in All the World's Regions, and is Highest in Developed Countries [g/capita/day, 2009]



Ranganathan J et al. (2016). Shifting diets Toward a sustainable food future. World Resources Institute. doi:10.2499/9780896295827_08

Dietary trends and income.

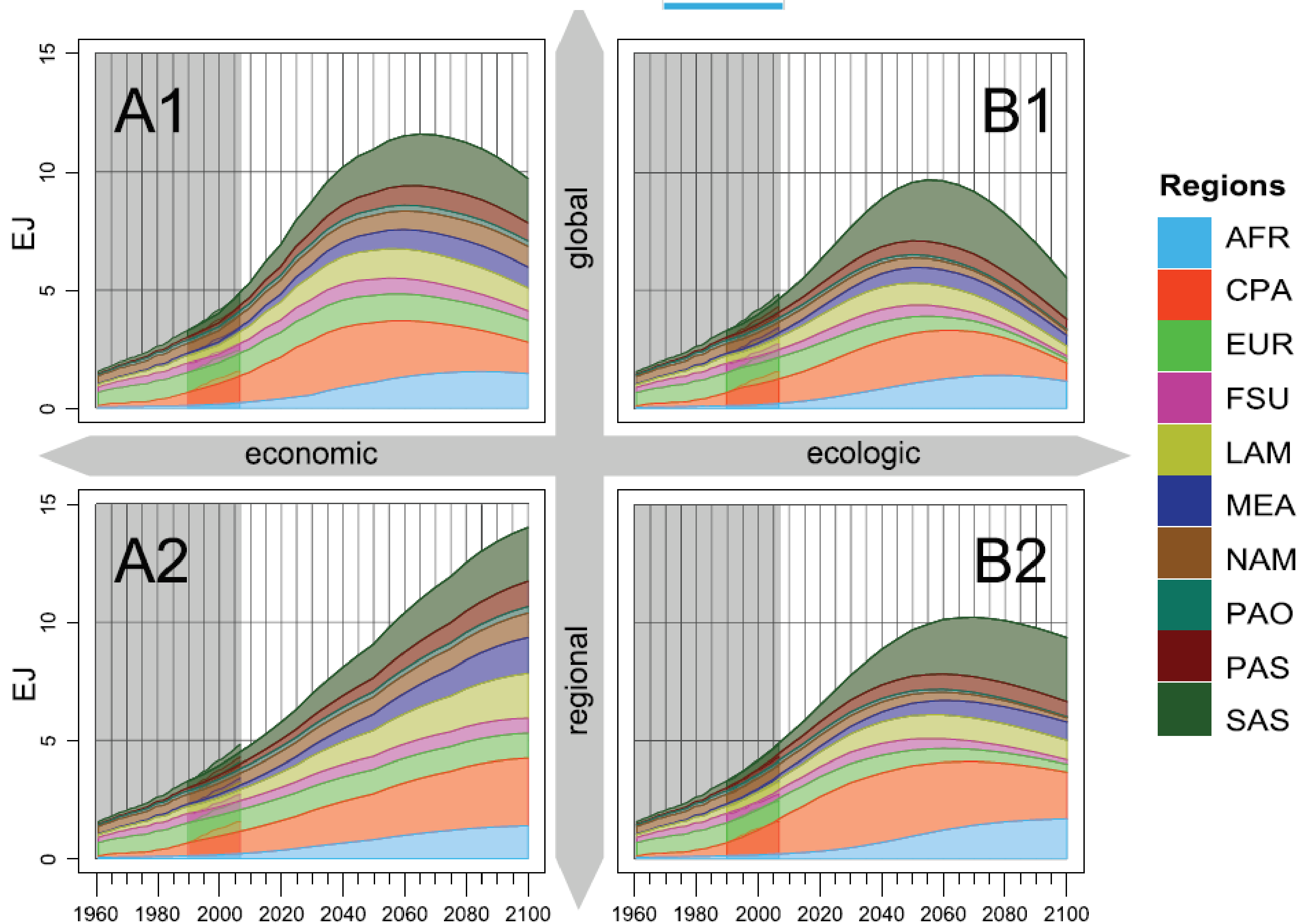
European Commission



Tilman, D., Clark, M. (2014). Global diets link environmental sustainability and human health. Nature 515, 518–522. doi:10.1038/nature13959

nature

Animal-based food energy demand



Bodirsky, B.L. et al. 2015. Global Food Demand Scenarios for the 21st Century. PLoS One 10, e0139201

International Agency for Research on Cancer

World Health Organization

PRESS RELEASE
N° 240

26 October 2015

IARC Monographs evaluate consumption of red meat and processed meat

Lyon, France, 26 October 2015 – The International Agency for Research on Cancer (IARC), the cancer agency of the World Health Organization, has evaluated the carcinogenicity of the consumption of red meat and processed meat.

Red meat

After thoroughly reviewing the accumulated scientific literatur
countries convened by the IARC Monographs Programme
probably carcinogenic to humans (Group 2A), based on *limited*
causes cancer in humans and *strong* mechanistic evidence su

Limited empirical evidence, strong mechanistic evidence: carcinogenic effect or red meat

This association was observed mainly for colorectal cancer, but associations were also seen for pancreatic cancer and prostate cancer.

Processed meat

Processed meat was classified as *carcinogenic to humans*
humans that the consumption of processed meat causes color

Sufficient evidence: processed meat causes colorectal cancer

Meat consumption and its effects

The consumption of meat varies greatly between countries, with from a few percent up to 100% of people eating red meat, depending on the country, and somewhat lower proportions eating processed meat.

The experts concluded that each 50 gram portion of processed meat eaten daily increases the risk of colorectal cancer by 18%.

"For an individual, the risk of developing colorectal cancer b
meat remains small, but this risk increases with the amount of
of the IARC Monographs Programme. "In view of the large r
meat, the global impact on cancer incidence is of public health

For an individual: risk remains small
For population: importance for public health

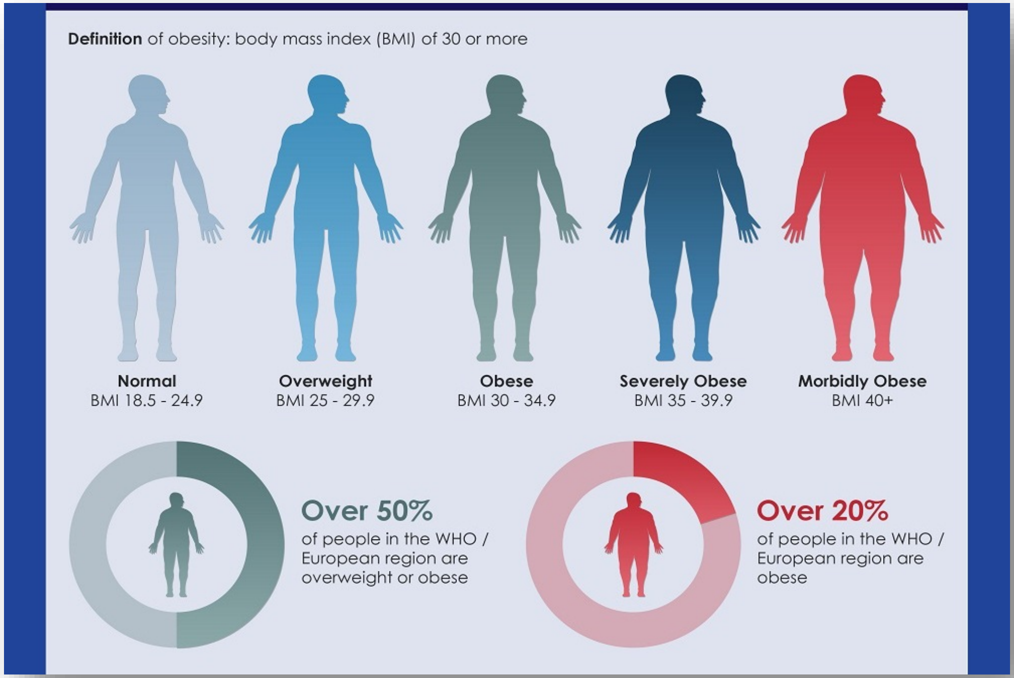
The IARC Working Group considered more than 800 studies that investigated associations of more than a dozen types of cancer with the consumption of red meat or processed meat in many countries and populations with diverse diets. The most influential evidence came from large prospective cohort studies conducted over the past 20 years.

Public health

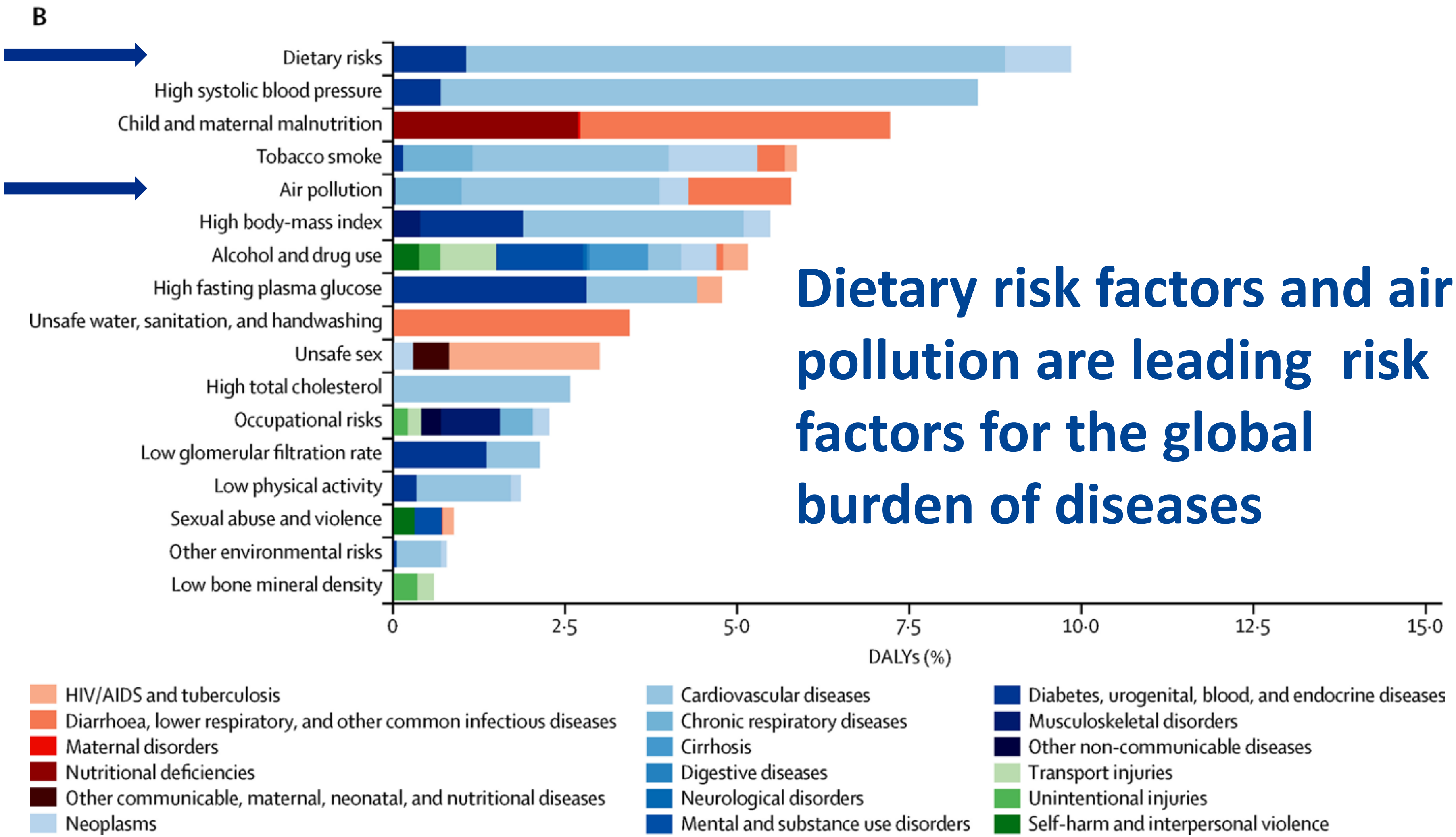
"These findings further support current public health recommendations to limit intake of meat," says Dr Christopher Wild, Director of IARC. "At the same time, red meat has nutritional value. Therefore, these results are important in enabling governments and international regulatory agencies to conduct risk assessments, in order to balance the risks and benefits of eating red meat and processed meat and to provide the best possible dietary recommendations."

Non-communicable diseases – diet related health problems

- The European Region is the **most severely affected** by noncommunicable diseases (NCDs)
- Collectively, cardiovascular disease, diabetes, cancer account for **86% of premature mortality**
- Globally, they account for 60% of NCD deaths and **40% of all deaths in 2010**



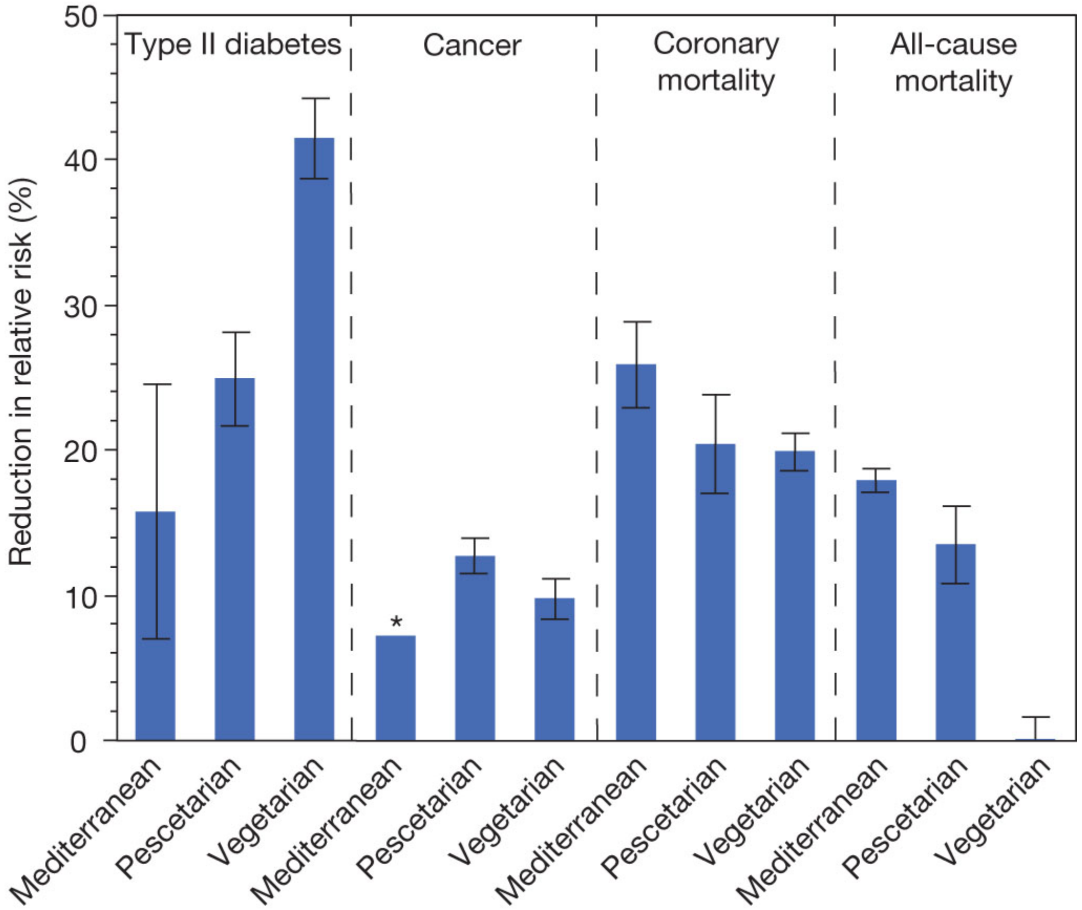
Burden of disease attributable to main risk factors (2013):



Dietary risk factors and air pollution are leading risk factors for the global burden of diseases

Forouzanfar, M.H. et al., 2015. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990-2013: A systematic analysis for the Global Burden of Disease Study 2013. Lancet 386, 2287–2323. doi: http://dx.doi.org/10.1016/S0140-6736(15)00128-2

Diet and health - ten million person-years of observations across eight study cohorts



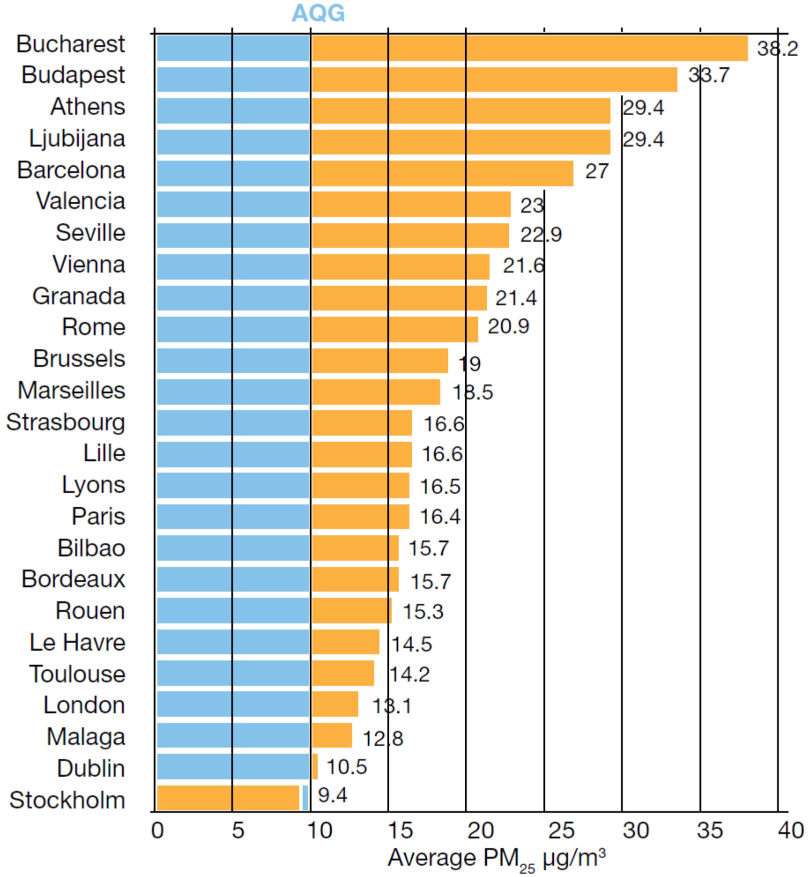
Tilman, D., Clark, M. (2014). Global diets link environmental sustainability and human health. Nature 515, 518–522. doi:10.1038/nature13959

nature

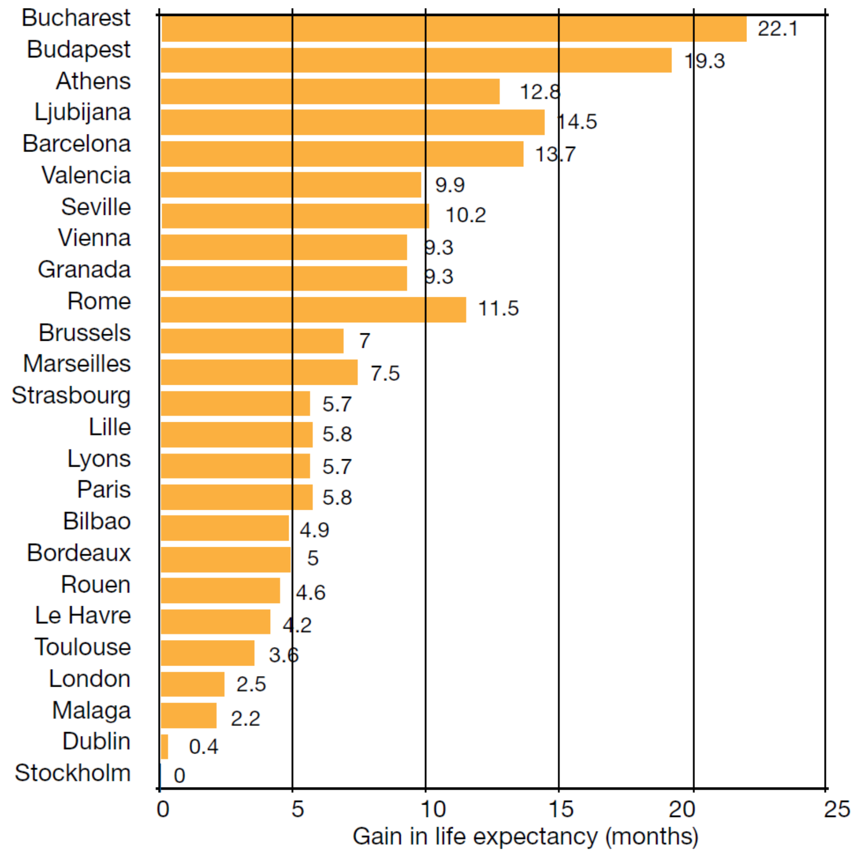
Exceeding the WHO guideline level on PM2.5 leads to a burden on mortality of nearly 19 000 deaths per year. The associated costs would reach €30 billion annually (Pascal et al., 2013).

European Commission

PM2.5 levels in 25 EU cities [µg /m3]



predicted gain in life expectancy from complying with WHO guideline [month]



The Aphekom project. From: WHO, 2016. Health risk assessment of air pollution: General principles.

Food and nutrition security

"Food and nutrition security exists when all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life."

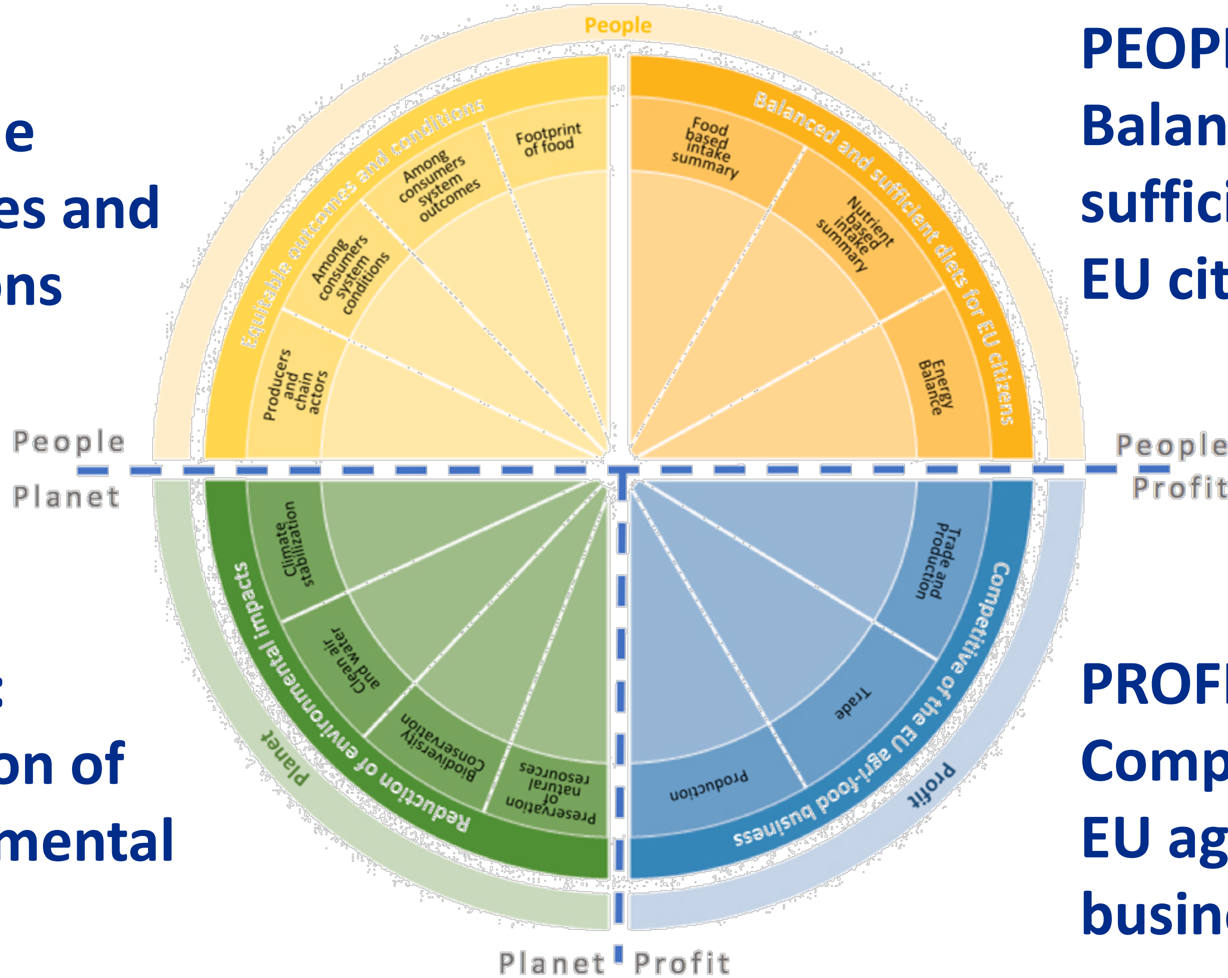
UN/FAO Committee for World Food Security, 2012. Coming to Terms with Terminology 1–16.

Sustainable Food and Nutrition Security: SUSFANS Food and nutrition policy goals

European Commission

PEOPLE: Equitable outcomes and conditions

PEOPLE: Balanced and sufficient diet for EU citizens'

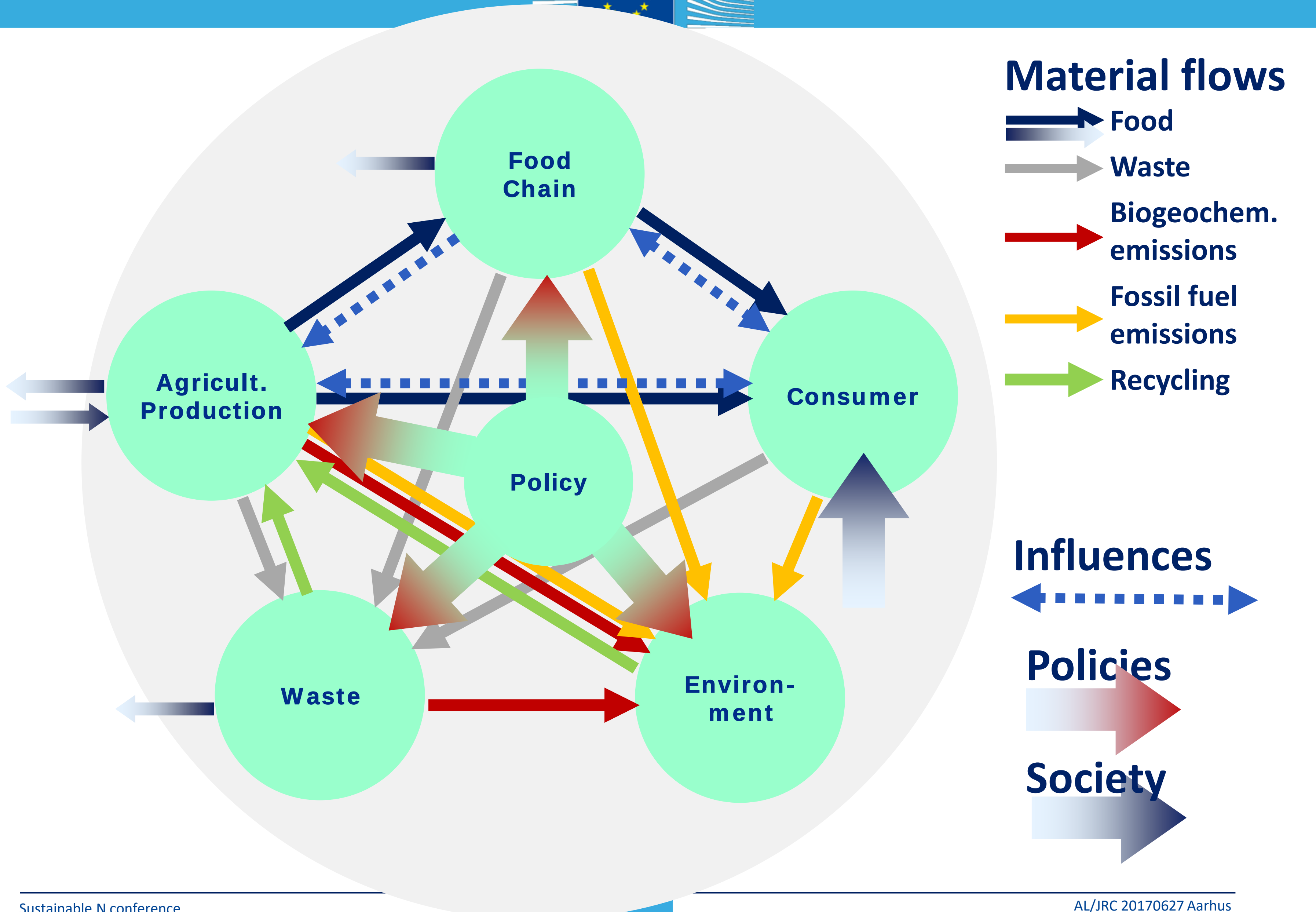


PLANET: Reduction of environmental impacts

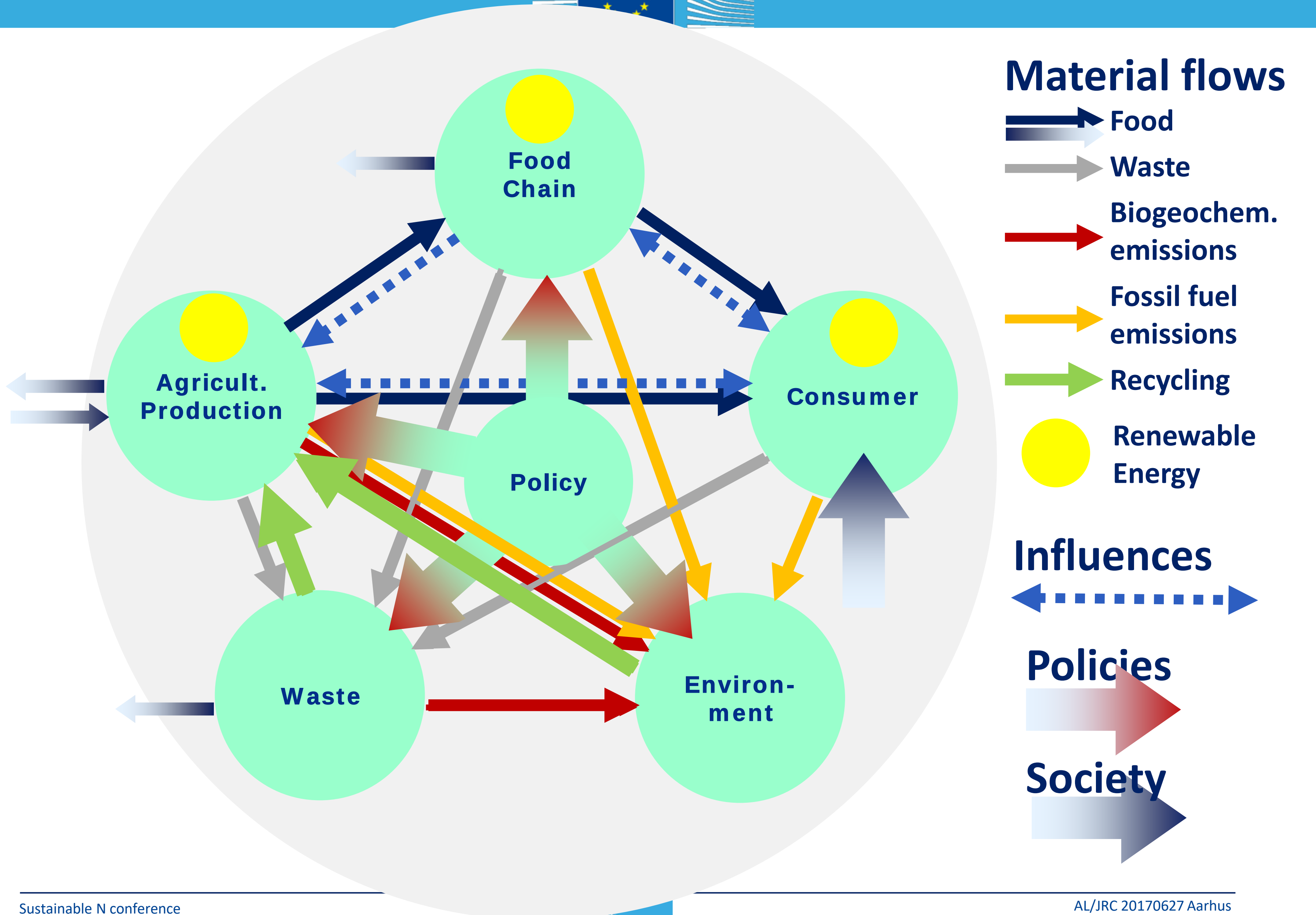
PROFIT Competitiveness of EU agri-food business

Zurek, M. et al. (2017). Sustainability metrics for the EU food system: a review across economic, environmental and social considerations. SUSFANS deliverabe D1.3.

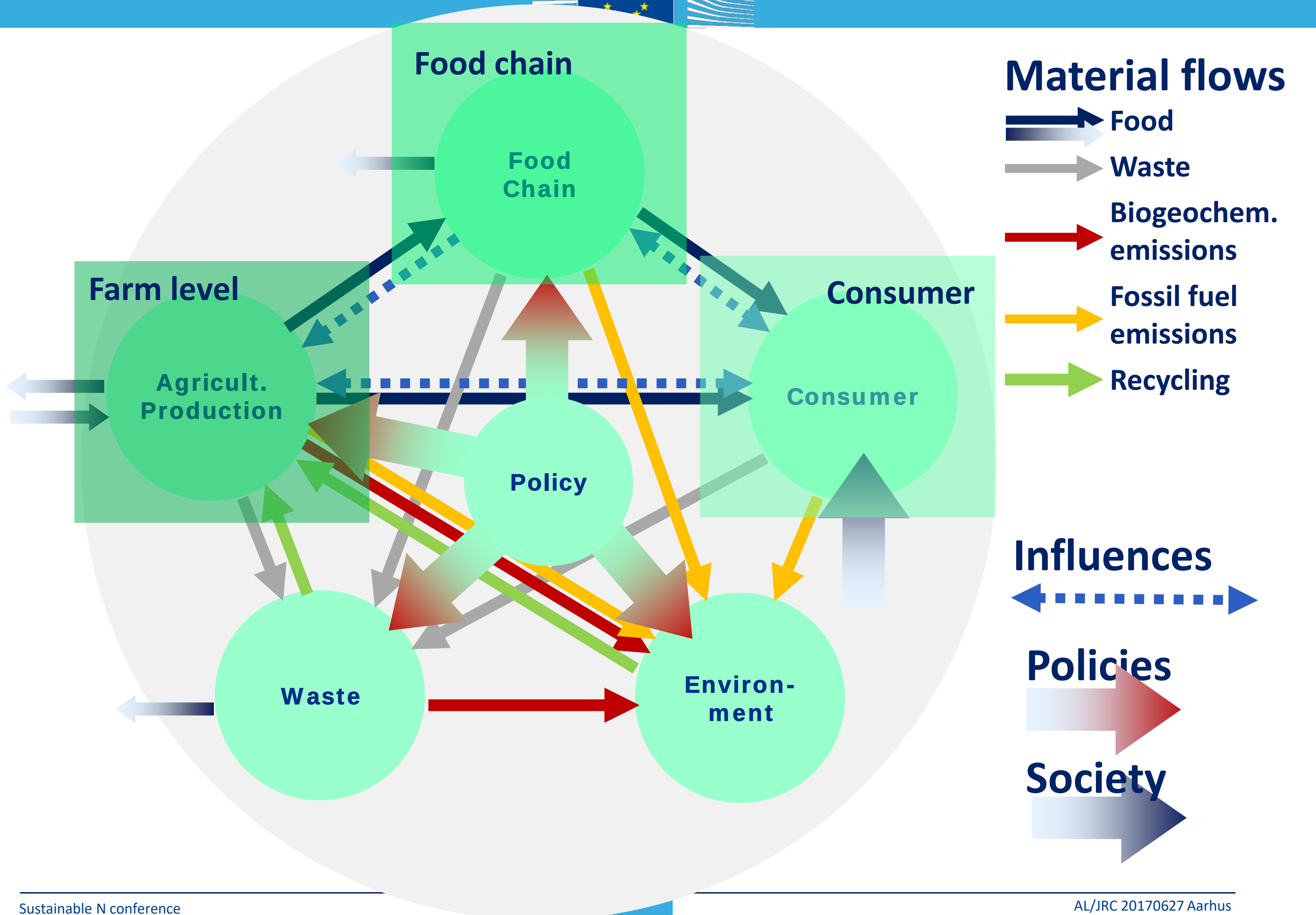
The food system: a pentagon



What can be done?



How can it be achieved?



Do mitigation options for agriculture exist?

Livestock disease management - Use of sexed semen for breeding dairy replacements - Genetically improved cow replacement rate - Animal breeding for enhanced productivity - Livestock selection based on growth, milk production and fertility - Use of products to increase production (meat or milk) per animal (like somatotropin) - Feed additives to reduce CH_4 (lipids, nitrates or sulphates, propionate precursors, plant bioactive compounds) - Breeding low methane emissions in ruminants - Vaccination against methanogenic bacteria in the rumen - Develop cross-breeding with lower emissions - Change fodder composition, favouring non-methanogenic compounds (increase sugar, tannins…) - Use of antibiotics to regulate microorganisms producing methane in the rumen - Use of biotechnology to control microorganisms in the rumen - Feed advisory tool - Optimised feed strategies (multi-phase feeding) - Changes in composition of animals' diet (optimising feed mix in ruminants) - Low nitrogen feed - Genetic improvement of cattle based on feed use efficiency - Increase concentrates in feed rations - Optimised manure storage and application - Covering slurry pits - Incorporation of slurry - Decrease the quantity of manure stock - Optimise the type of manure produced to balance N_2O/CH_4 emissions - Anaerobic digestion - Produce dihydrogen from manure in anaerobic conditions - Slurry acidification - Rice - Soil and nutrient management plans - Improved nitrogen efficiency - Variable Rate Technology (VRT) - Precision farming - Genetic improvement of crops for better nitrogen uptake and use efficiency - Delay in applying mineral N in crops that have had slurry applied - Reducing soil compaction and avoiding fertilization in the traffic lanes - Biological N fixation in rotations and in grass mixes - Increase legume share in temporary grassland - Substitution of mineral fertilizer by N from legumes - Use of urease inhibitors and next-generation nitrification inhibitors - Nitrification inhibitors - Modify microbial communities in the soil, introducing microorganisms which reduce N_2O and N_2 - Maintain soil pH at suitable level for crop/grass production - Burn - Agro-forestry, short rotation forestry - Maintaining permanent grasslands - Conversion of arable land to grassland to sequester carbon in the soil - Woodland creation (afforestation, including new shelterbelts, hedgerows, woody buffer strips and in-field trees) - Woodland management: preventing deforestation - Woodland management (including existing shelterbelts, hedgerows, woody buffer strips and in-field trees) - Improving grassland management (e.g. optimizing productivity, livestock density, nutrient management, grass varieties) to increase carbon sequestration - Extend the perennial phase of crop rotations - Leaving Crop Residues on the soil surface - Use cover/catch crops, green manure, and reduce bare fallow - Restauration of degraded soils to increase the production and stock of organic matter - Increase biomass production by optimising the input use, increasing carbon return to the soil - Select crops providing higher carbon return to soils - Measures targeting C-sequestration (reduced tillage, crop rotation, cover crops...) - Reduced Tillage - Zero Tillage - Biochar applied to soil - Wetland and peatland conservation/restoration - Fallowing histosols - Carbon calculator - Improved on-farm energy efficiency - Reduce the use of fossil energy use on-farm in buildings and machinery - Use of solar energy to dry agricultural products - Use of solar, wind, and geothermal energy - Biofuel production and use on site - Produce energy on-farm through biomass burning to decrease CO_2 emissions -

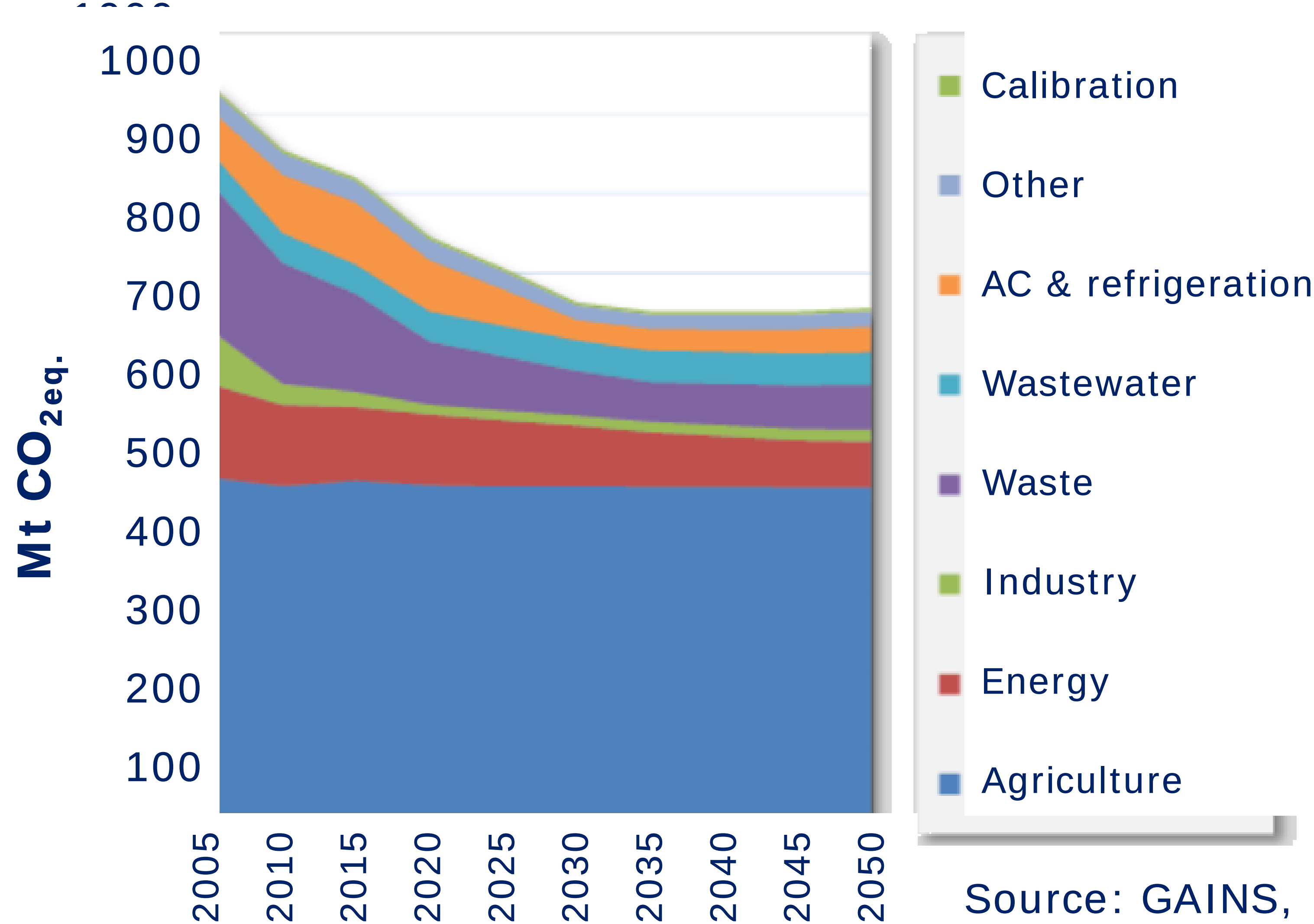
Farm scale mitigation measures are numerous …

Mitigation mechanisms	Changes provoked	Gas(es) targeted	Other gases affected
HERD	Improves herd productivity, but not individual one	CH_{4Ent}	CH_{4Man}, N_2O_{Man}
BREED	Improves animal productivity	CH_{4Ent}	CH_{4Man}, N_2O_{Man}
METHGEN	Additives or breeding reducing selectively CH_4 production in rumen	CH_{4Ent}	--
FEED	Adjust rations to (energy, N content) feed needs	CH_{4Ent}/ N_2O_{Man}	CH_{4Man} (through VS)
MANSYS	% manure in each MMS	CH_{4Man}, N_2O_{Man}	
ADIG	Anaerobic digesters, to reduce emissions form manure and produce energy	CH_{4Man}, N_2O_{Man}	CO_2 energy
MANEF	Additives, etc, affecting directly emission factors	CH_{4Man}/ N_2O_{Man}	--
RICE	Management practices (e.g. aeration)	CH_{4Rice}	--
NMANAG	Improved use of available sources (% each type, timing....)	N_2O_{Direct}	N_2O_{ATD}, N_2O_{LEACH}
LEGU	Increase leguminous share	N_2O_{Direct}	N_2O_{ATD}, N_2O_{LEACH}, N_2O_{Man}, CH_{4Man}
NEF	Substances/ techniques to reduce EFs	N_2O_{Direct}	--
BURN	Reduce burnt biomass	L_{fire}	
LUSE	Increasing carbon sequestration/Reducing carbon losses	CO_2	CH_4, N_2O
LMAN	Reducing carbon losses	CO_2	N_2O
ORGSOILS	Increasing carbon sequestration/preventing carbon losses	CO_2	CH_4, N_2O
ENER	Measures to reduce farm energy use	CO_2	
GLOBAL	Measures to reduce total farm GHG emissions	CH_4, N_2O, CO_2…	All
CIRCULAR	Measures to reduce total GHG emissions by optimising biomass streams	CH_4, N_2O, CO_2…	All

Leip, A. et al.. Mitigation measures in the Agriculture, Forestry, and Other Land Use (AFOLU) sector - Quantifying mitigation effects at the farm level and in national greenhouse gas inventories . JRC Report, forthcoming

Trends in non sectors outside of the EU-Emissions Trading System: C-emissions go down, agri-emissions remain stable

European Commission



Source: GAINS, IIASA

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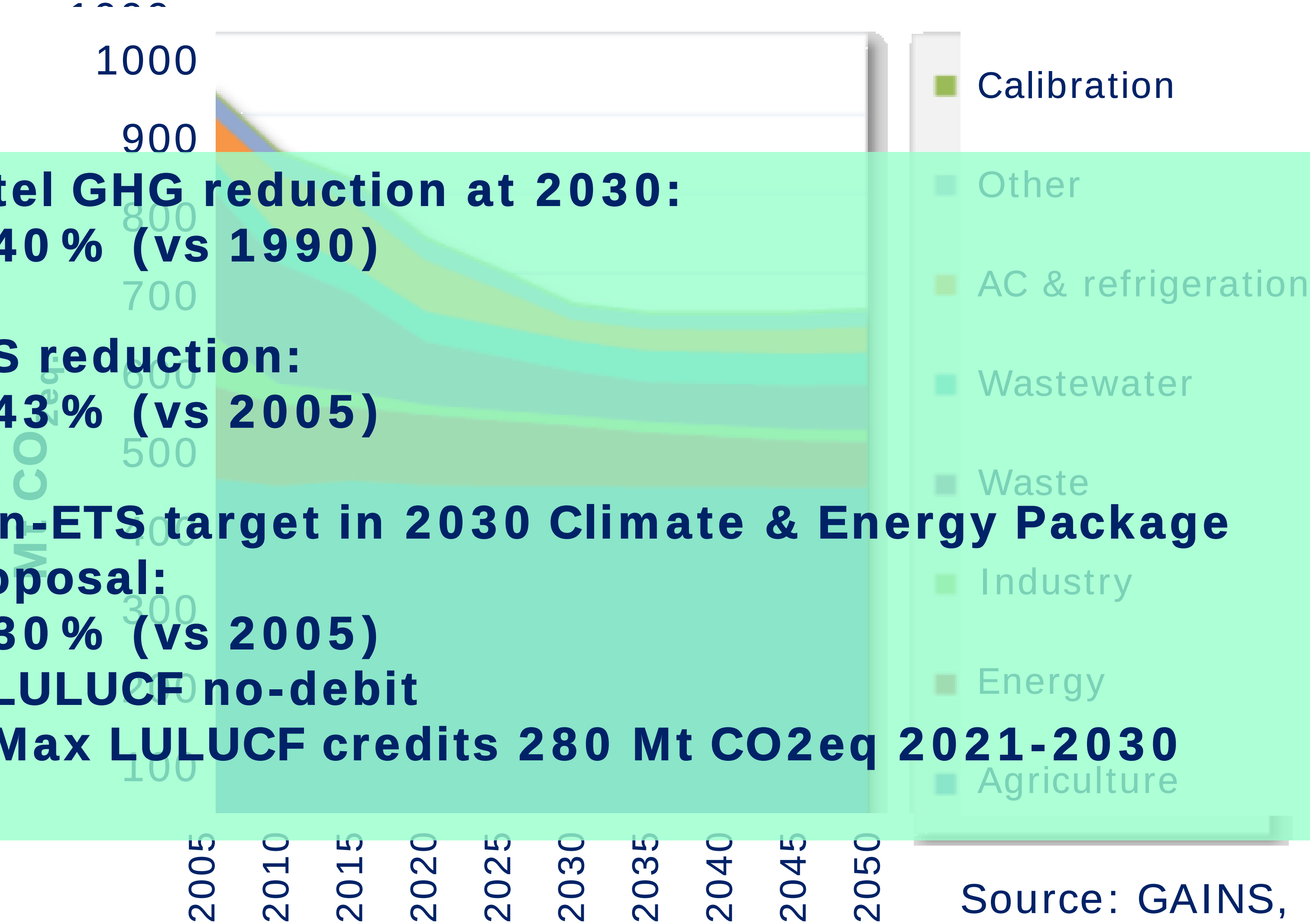


Totel GHG reduction at 2030:

- **40% (vs 1990)**

ETS reduction:

- **43% (vs 2005)**

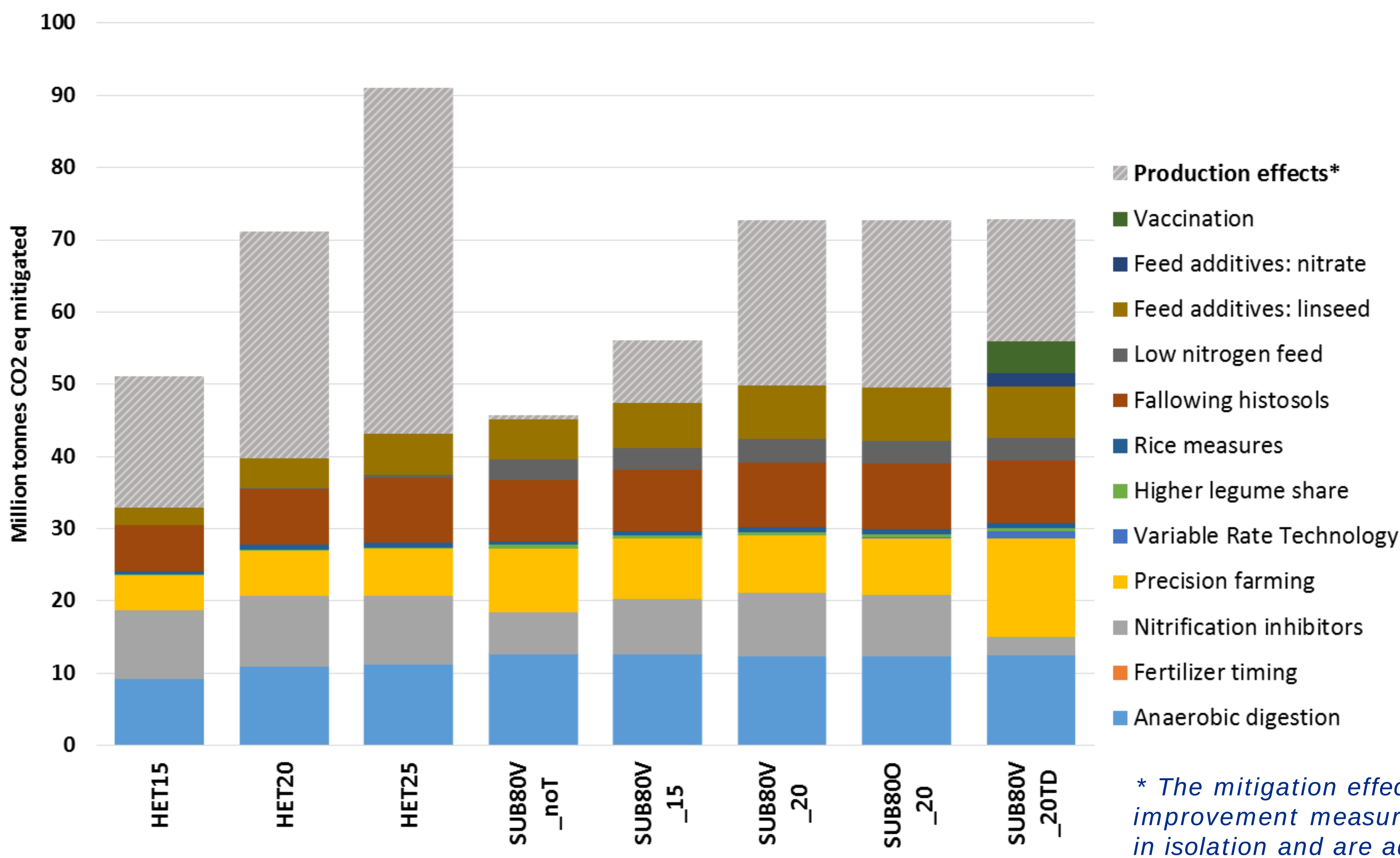
Non-ETS target in 2030 Climate & Energy Package proposal:

- **30% (vs 2005)**
- **LULUCF no-debit**
- **Max LULUCF credits 280 Mt CO2eq 2021-2030**

Source: GAINS, IIASA

Contribution of farm level mitigation technologies to total mitigation

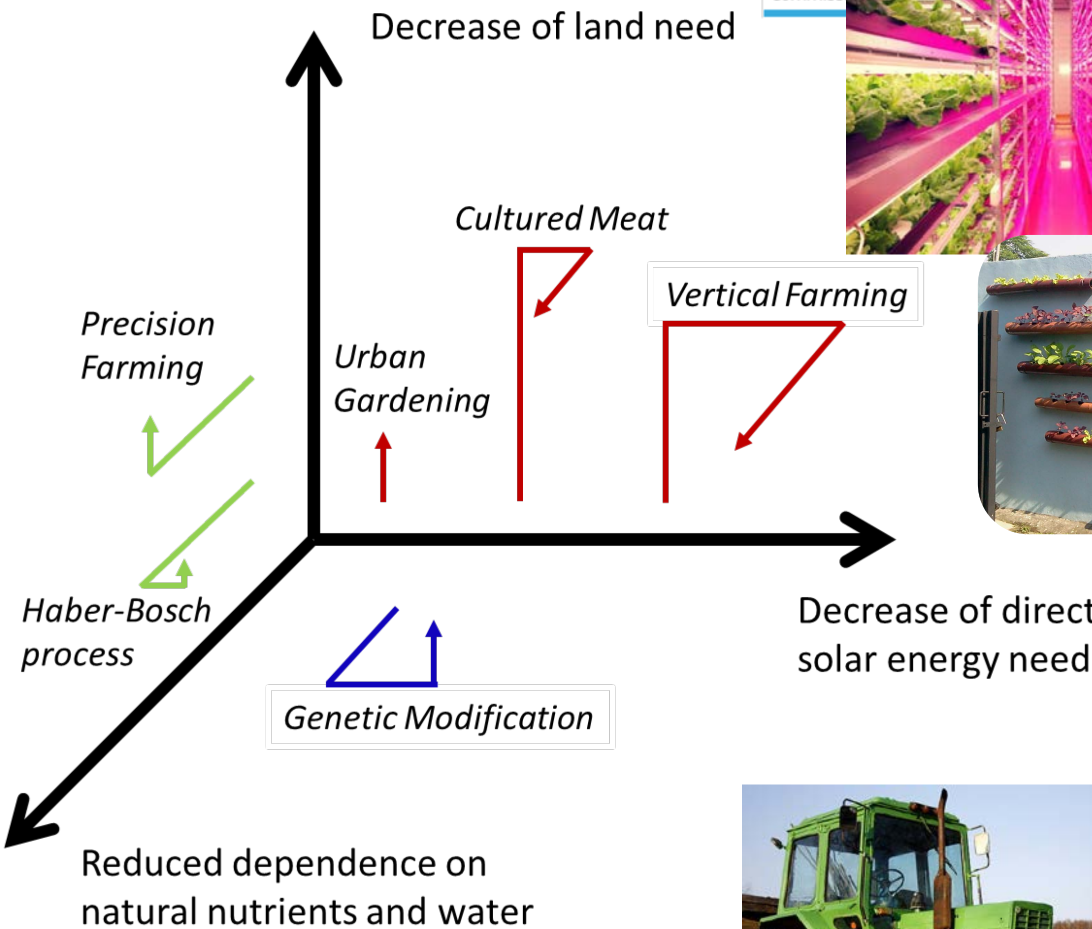
European Commission

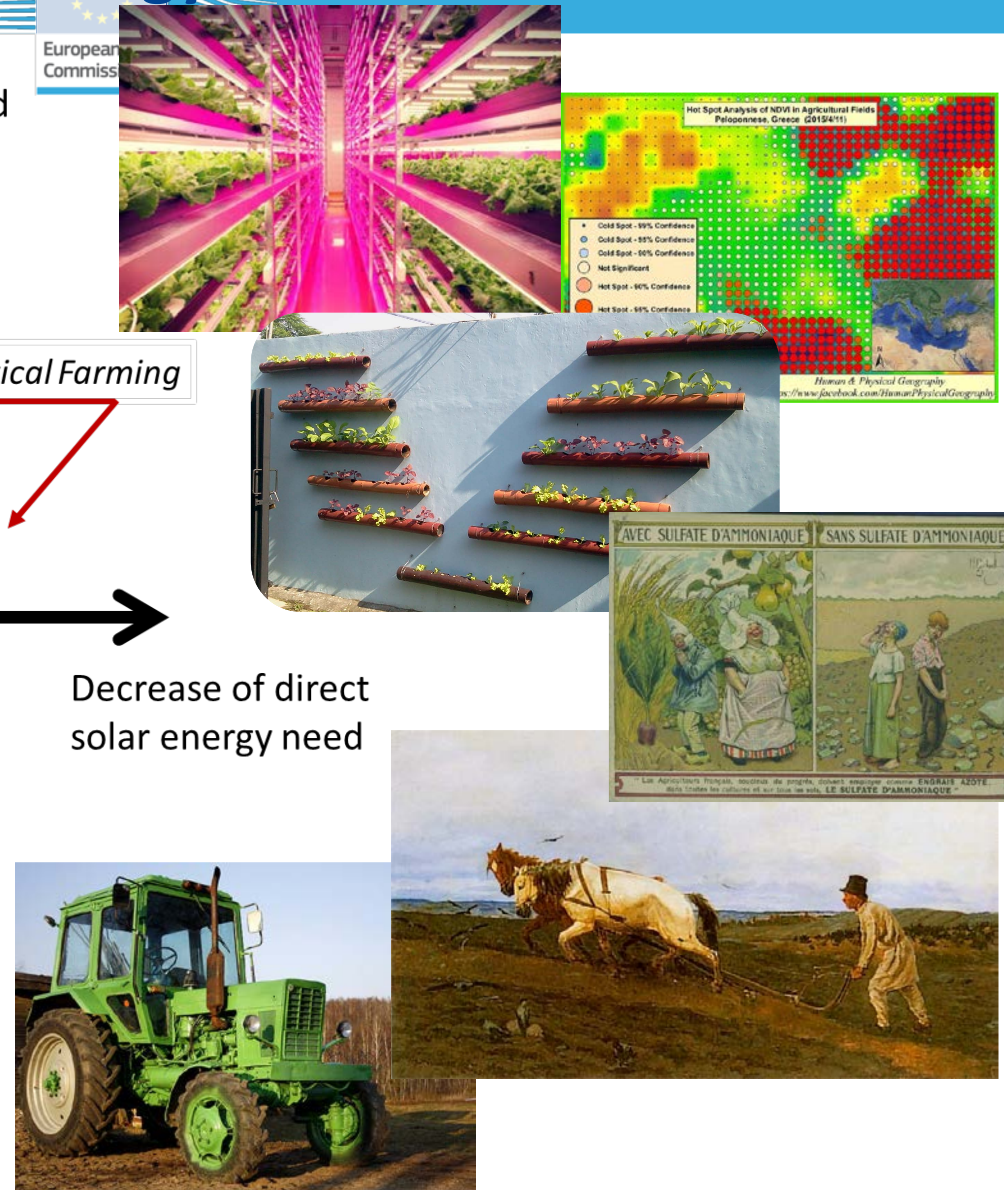


** The mitigation effects linked to genetic improvement measures cannot be analysed in isolation and are added to mitigation achieved by changes in production.*

Pérez Domínguez et al. 2016. An economic assessment of GHG mitigation policy options for EU agriculture (EcAMPA 2), JRC Science for Policy Report.

Substitution of land, soil and direct solar energy with knowledge and renewable energy?





Winiwarter et al., 2014. A European perspective of innovations towards mitigation of nitrogen-related greenhouse gases. Curr. Opin. Environ. Sustain. Elsevier B.V. 9-10, 37–45.

Opportunities for R&I Breakthroughs

Presentation John Bell,
Director Bioeconomy,
DG Research & Innovation
12/10/2016 - FOOD 2030 conference

How to make agricultural practices more sustainable? Modernization and Simplification of the Common Agricultural Policy

European Commission

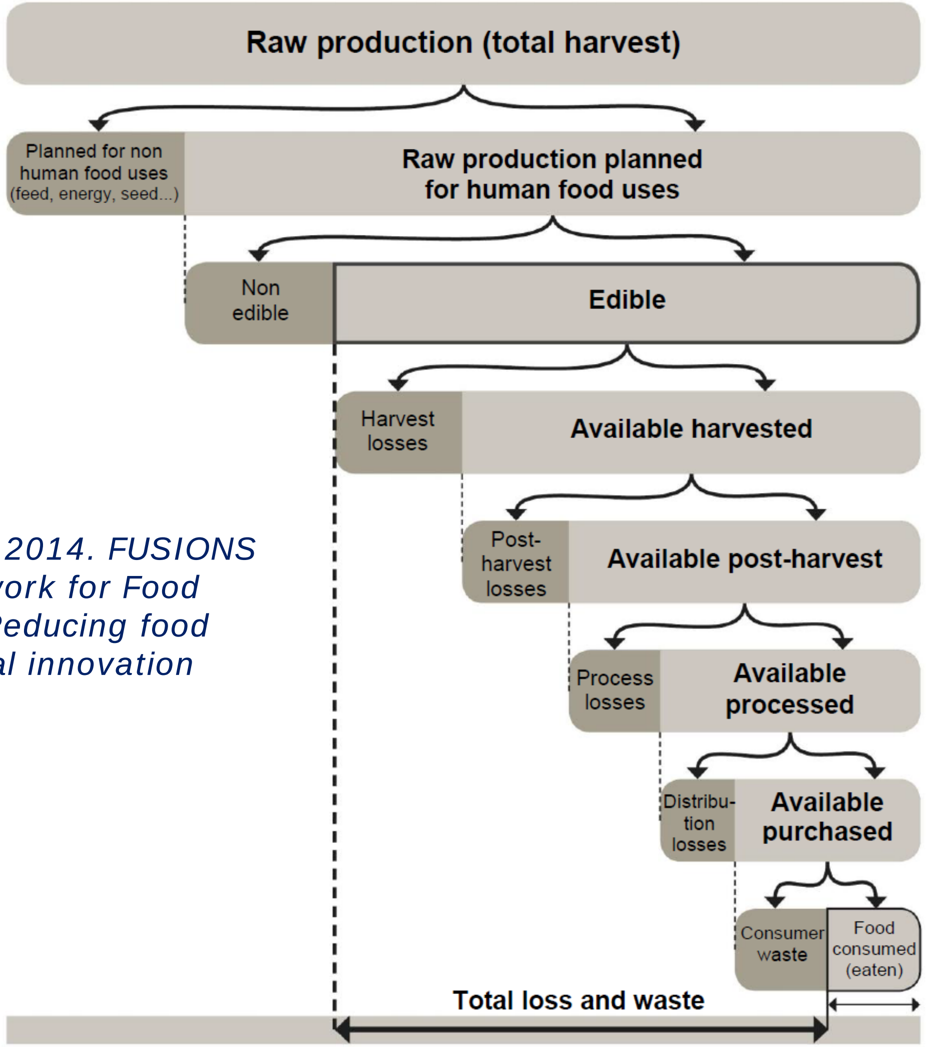
- Public consultation (closed in May) on 5 options .
- Outcome will be communicated in a Conference on 7th July 2017

- **Option 1** baseline: change nothing
- **Option 2** no policy: do nothing (dismantle CAP)
- **Option 3** programming the CAP against EU priorities
- **Option 4** better link farm practices to EU-wide environment/climate action targets.
- **Option 5** redistribution of support from larger to smaller and environmentally-friendly farms. This option promotes stricter environmental requirements, short supply chains and local markets.

Schematic representation of the definition of food losses and waste along the food chain

European Commission

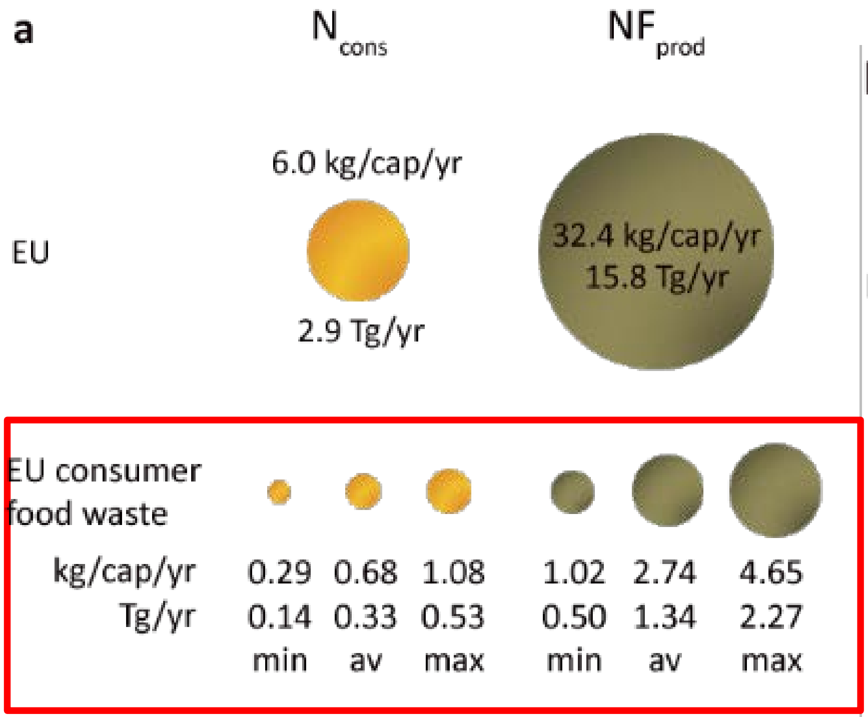
Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea).



Östergen, K. et al., 2014. FUSIONS Definitional Framework for Food Waste. ***FUSIONS*** *Reducing food waste through social innovation*

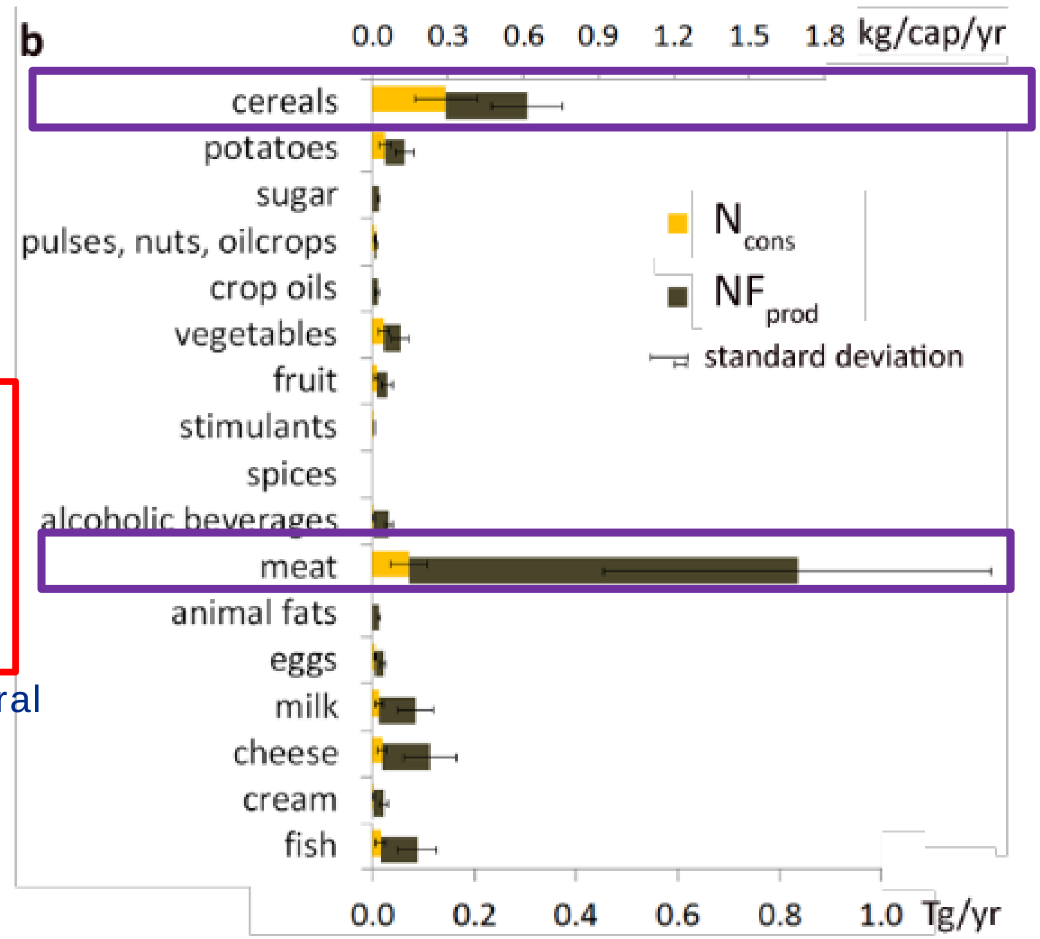
HLPE, 2014. Food losses and waste in the context of sustainable food systems. A report by The High Level Panel of Experts on Food Security and Nutrition of the Committee on World Fod Security. Available at: http://www.fao.org/3/a-i3901e.pdf.

Avoidable food waste



1.34 Tg/yr = equivalent to the use of mineral fertiliser by the UK and Germany combined

NF of avoidable food waste

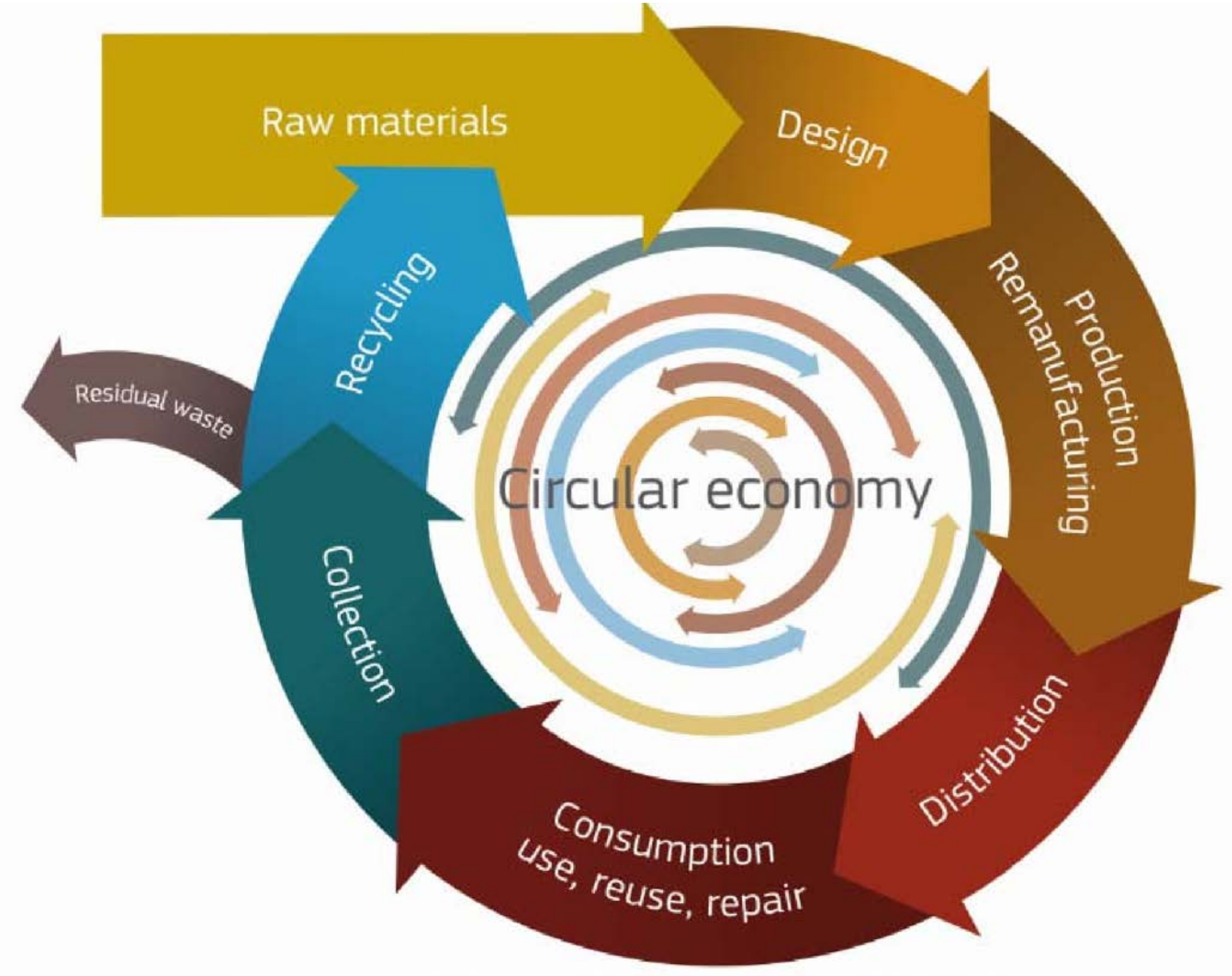


Vanham D, Bouraoui F, Leip a, Grizzetti B, Bidoglio G. Lost water and nitrogen resources due to EU consumer food waste. Environ Res Lett. IOP Publishing; 2015;10: 084008. doi:10.1088/1748-9326/10/8/084008

Closing the loop – EU action plan for the Circular Economy

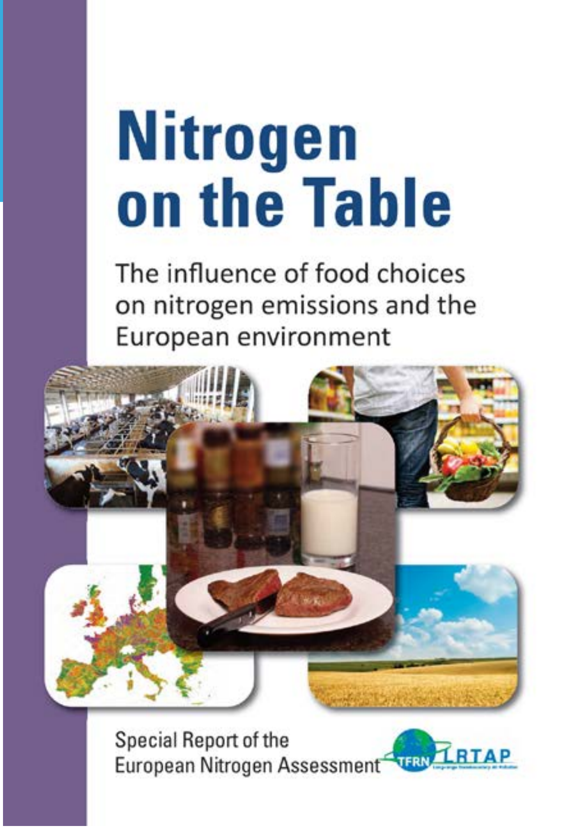
European Commission

Food waste one of the priority areas of the Circular Economy action plan



Major environmental effects of minus 50% meat and dairy consumption

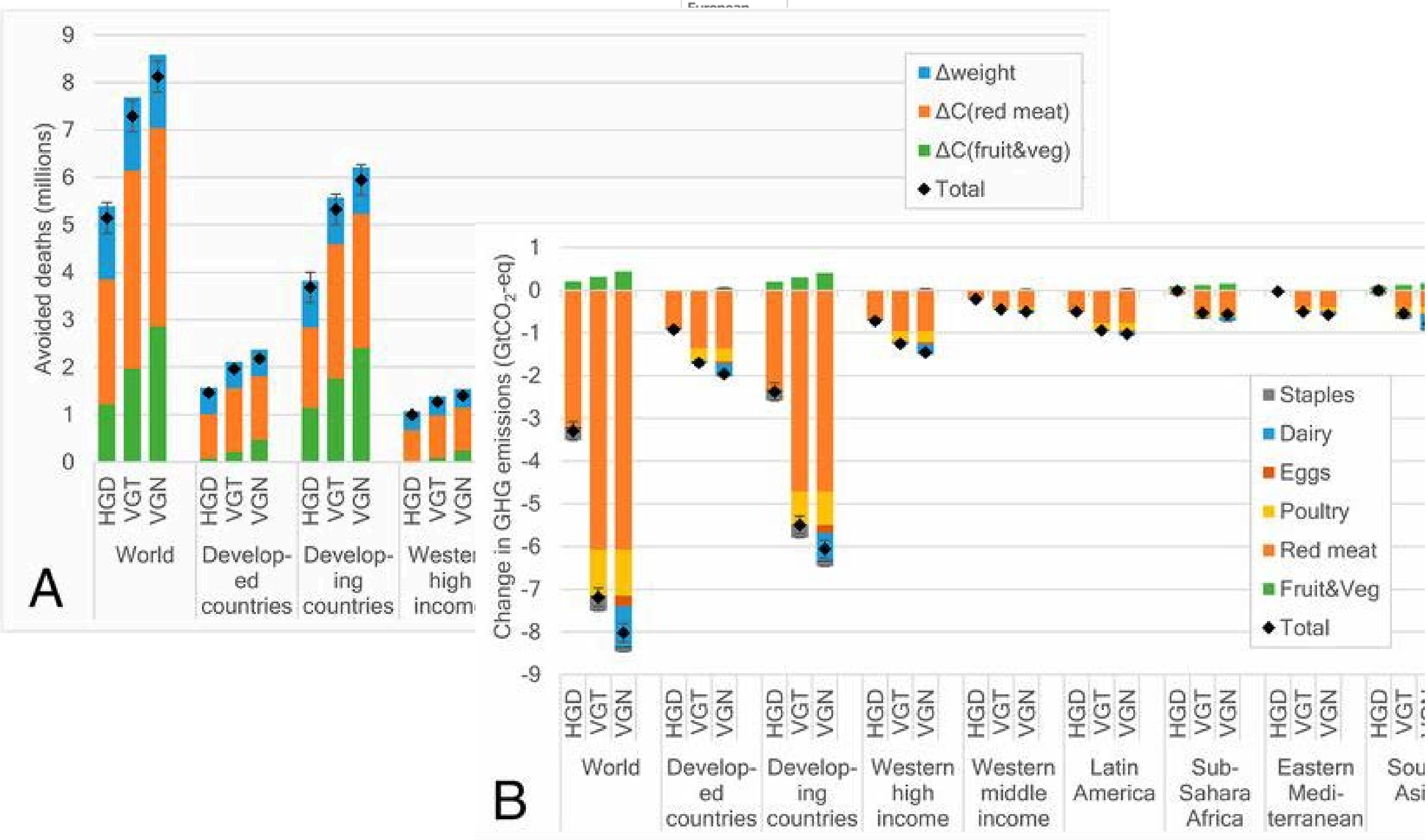
- Around 40% lower nitrogen emissions from EU agriculture
- Soy import could be reduced by 75%
- Freeing up land-use for other purposes
- **Greening scenario**
  - 43% lower greenhouse gas emissions from agriculture
  - bio-energy production; extensification of land use
- **High prices scenario**
  - 25% lower greenhouse gas emissions
  - EU becomes a major exporter of cereals, increase from ~5 to max 170 million t/yr



- Intake of saturated fats reduced by 40%
- Red meat reduced from 207% to 107% of RMDI
- The intake of proteins remains well above recommended level

Westhoek, H. et al., 2015.

Health and environmental analysis of dietary change for the year 2050.

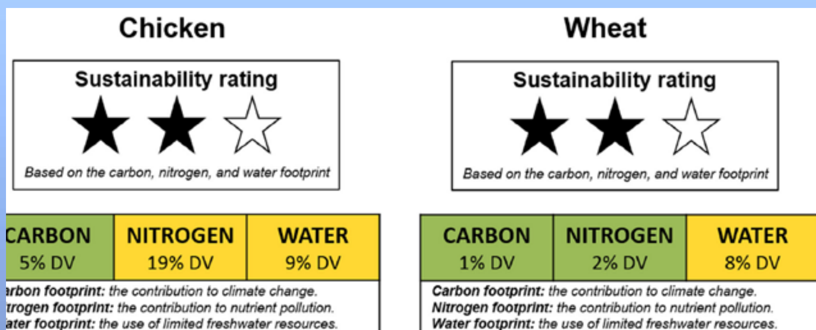


Springmann, M. et al. (2016). Analysis and valuation of the health and climate change cobenefits of dietary change. Proc. Natl. Acad. Sci. 113, 4146–4151. doi:10.1073/pnas.1523119113

How to engage the consumer?

European Commission

Environment



Leach, A.M. et al., 2016.

Health

Price

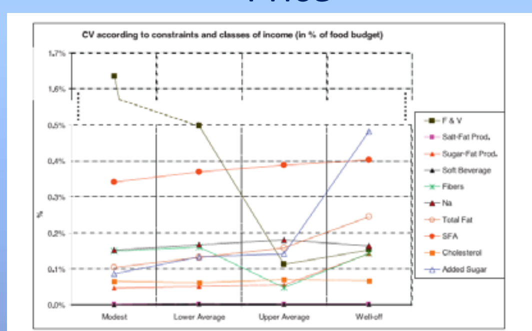
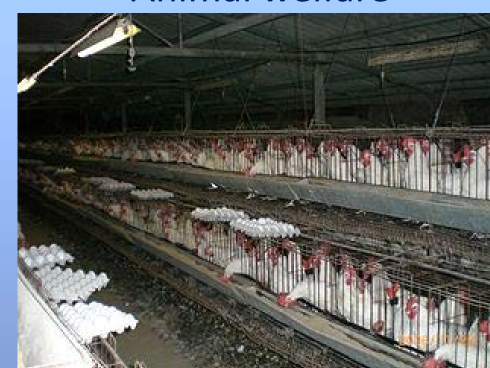


Fig. 1. Compensating variations associated with the imposition of all ten nutritional constraints, for each of the four types of consumers.

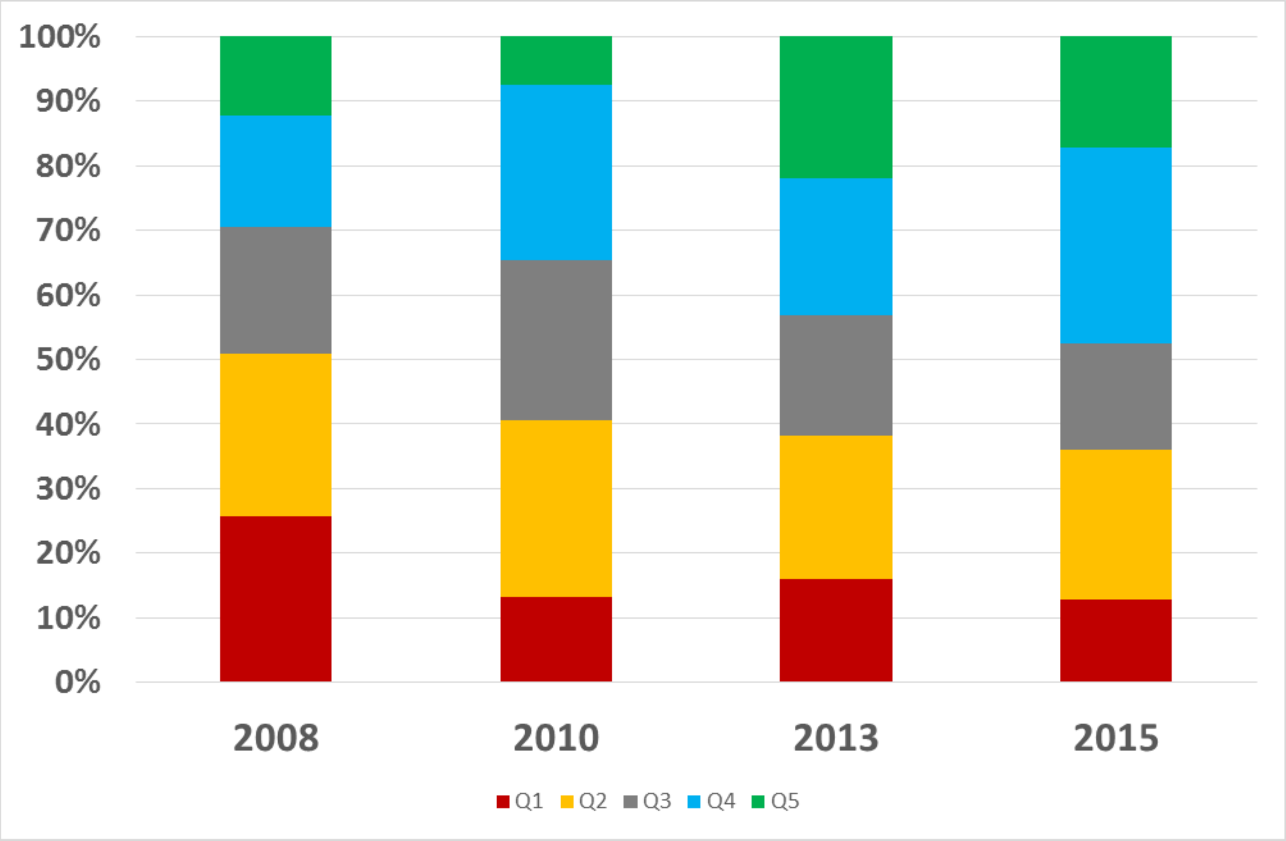
Irz, X. et al., 2015

Animal welfare



Thinking specifically about "Sustainably Produced", which of the following statements best describes your attitude towards the term?

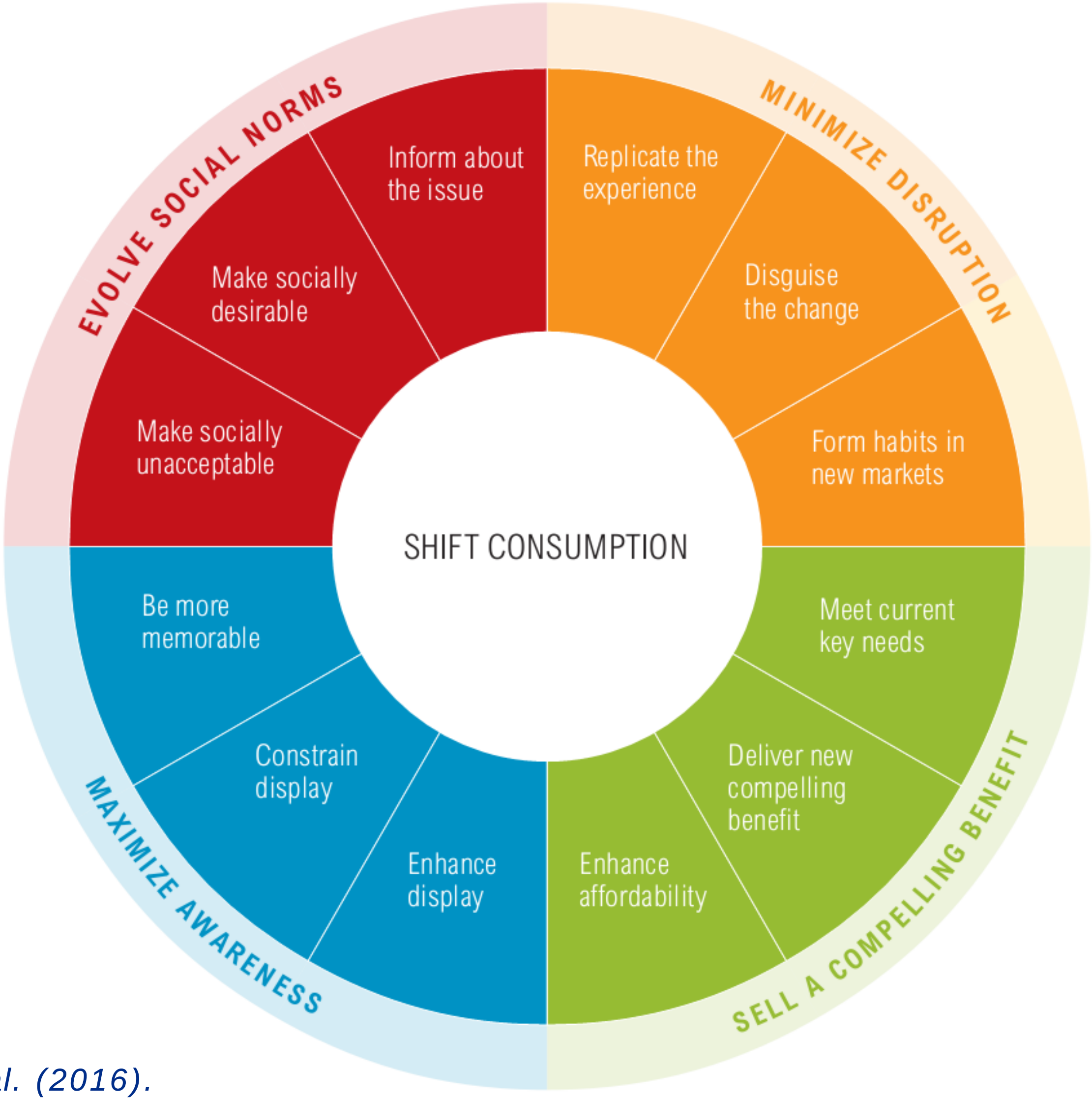
European Commission



- I actively / always try to buy food with this issue
- I sometimes try to buy food with this issue
- I consider the term to be a fad
- I have never heard of it before today
- I have heard of it but do not consider it important

David Hagen 2017, pers. Comm.

The Shift Wheel Comprises Four Strategies to Shift Consumption



Ranganathan, J. et al. (2016).
Shifting diets Toward a sustainable food future. World Resources Institute.

The different resources/powers governments have at their disposal to create incentives/discentives

- Information/educational
- Regulatory
- Taxing/subsidising
- Organizational and constitutional

Mello , 2008,
Hood, C., 1986. The tools of government. Chatham House Publishers.

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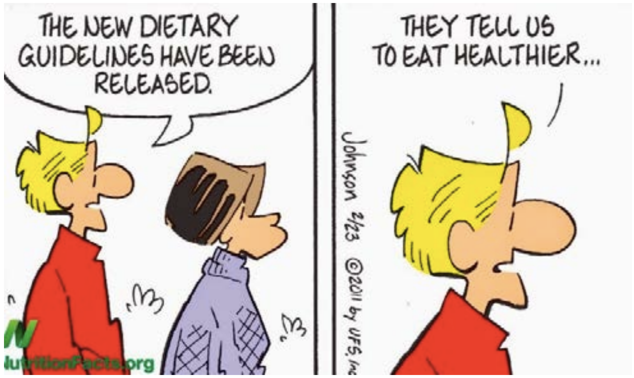
Although, the evidence points to the limited effectiveness of education/information strategies for behaviour change, this is a very common approach for promoting healthy and sustainable consumption



Only some countries are implementing Tax/subsidies on foods to the population at large or subsidies to disadvantaged consumers

- *In order to respond to wicked problems, it is necessary to implement a* ***comprehensive approach****, including educational, regulatory, taxing/subsiding and capacity-building resources*

Non-governmental developments….

European Commission

*Just because **the first in vitro hamburger cost $335,000** to produce doesn't mean we shouldn't start thinking about how factory-grown meat might transform our food system, the environment, and even our culture.*

Carolyn Mattick, Brad Allenby (2013) The future of meat
http://issues.org/30-1/carolyn/

*The year is 2019. World human population is approaching eight billion. Animal agriculture has become more concentrated and centralized than ever and is now a near monopoly, with just two companies controlling 98% of the American meat supply from hoof to hamburger. […] Within a week, the epidemic has metastasized. […] **Eating flesh becomes tantamount to playing Russian roulette. Within a week, human meat consumption effectively drops to zero**.*

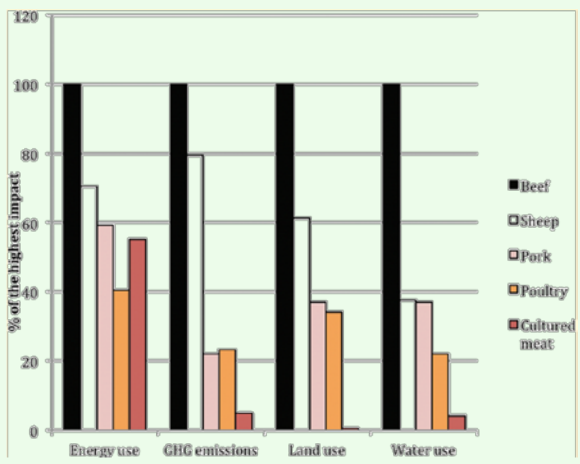
Jonathan Balcombe (2016) After meat
http://www.igi-global.com/chapter/after-meat/139636

*Food and agriculture accounts for about 5.9% of the global GDP. Global food retail sales alone account for about $4 trillion/year, and food accounts for 15% of what American households spend each year. **It is an industry ripe for disruption**.*

Peter Diamandis (2015) Feeding Tomorrow's Billions: Lab-Grown Meat Products, Vertical Farms, AI-Designed Recipes, and More

*"The world's over reliance on factory farmed livestock to feed the growing **global demand for protein is a recipe for a financial, social and environmental crisis**,"*

Jeremy Coller (2016) founder of the FAIRR initiative and chief investment officer at private equity company Coller Capital. http://uk.reuters.com/article/us-investors-food-idUKKCN11W0KH



Tuomisto and Teixeira de Mattos 2011

European Commission

- Questions
  i. How far could a combination of **improved farm level technical measures** and **shifts in consumption** go to improving the Nitrogen Use Efficiency of the overall food system of Europe? And what need the incentives be in order to realize this NUE improvement?
  ii. What is the **relative potential of dietary changes and food waste reduction** to reduce nitrogen air pollution and other environmental threats?
  iii. What are the **health effects** of a range of dietary patterns that generate less nitrogen pollution (ie. positive and negative)? Is it possible to identify particular dietary patterns that achieve health-environmental synergies?
  iv. To what extent can a stronger link between the scientific evidence on environment and health strengthen the case for controlling nitrogen pollution and optimizing diets to meet human health goals?

European Commission

- Questions

i. Supply options ⟷ **Mitigation** ⟷ Demand options

ii. Dietary Change ⟷ **Demand** ⟷ Waste reduction

iii. Nutrition ⟷ **Health** ⟷ Pollution

iv. Is nitrogen the new carbon?

THANK YOU – adrian.leip@jrc.ec.europa.eu