



EDGAR-FOOD: an unprecedented picture of evolving greenhouse gas emissions from food systems

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Food systems 'from farm to fork' contribute to achieving SDG goals



Action Tracks

- 1 - Ensure Safe & Nutritious Food for All
 - 2 - Shift to Sustainable Consumption Patterns
 - 3 - Boost Nature Positive Production
 - 4 - Advance Equitable Livelihood
 - 5 - Build Resilience to Vulnerab., Shocks & Stresses
- X-cutting levers: Gender, innovation, financing

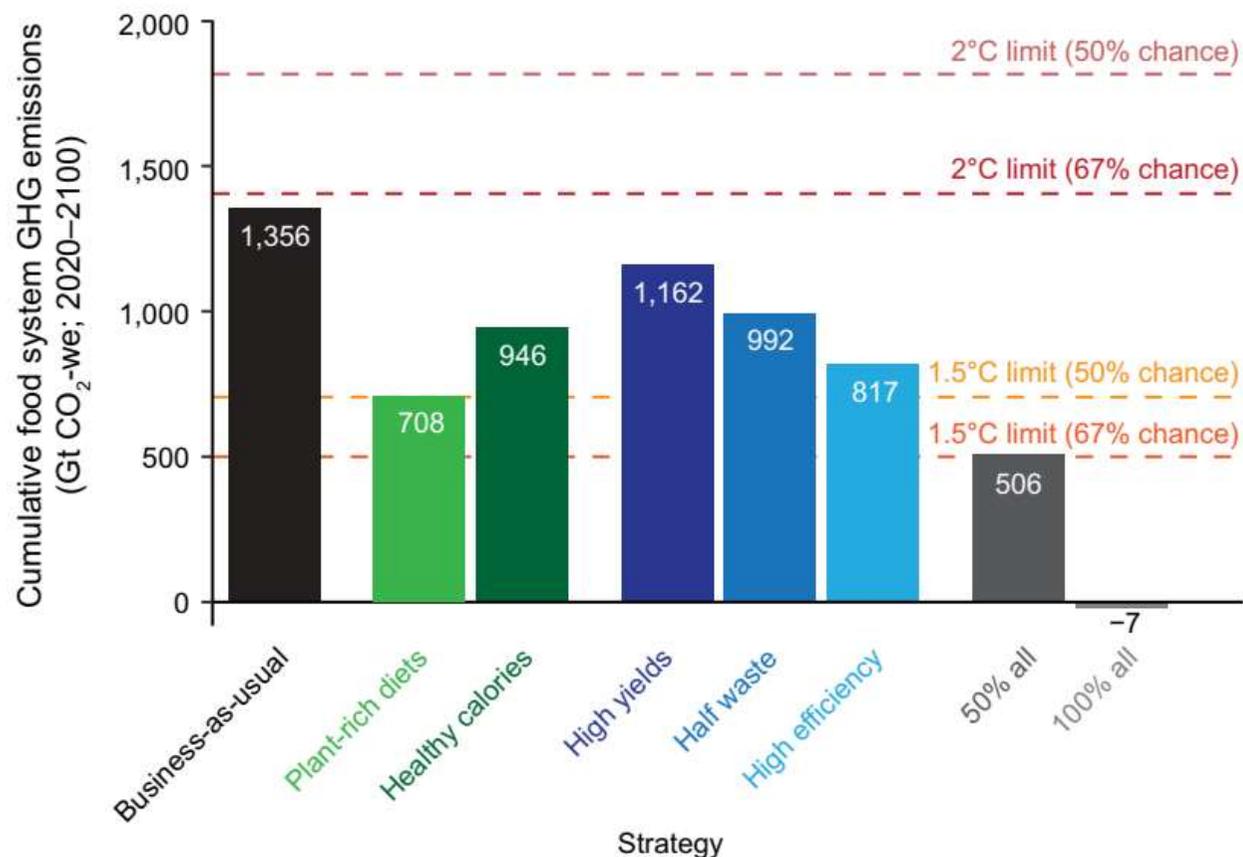
UN Food Systems Summit 2021



Direct and indirect effects of food systems on SDGs, Herrero et al., 2021



Food System and Climate Change



Clark et al. (2020)

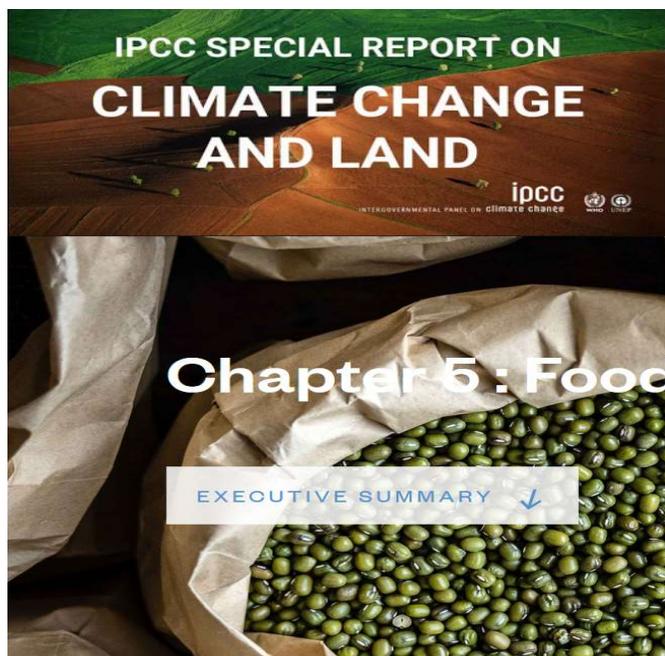
*Clark et al. show that even if fossil fuel emissions were immediately halted, **current trends in global food systems would prevent the achievement of the 1.5°C target** and, by the end of the century, threaten the achievement of the 2°C target.*

Meeting the 1.5°C target requires rapid and ambitious changes to food systems as well as to all nonfood sectors.

Food system activities emit greenhouse gases



Previous global estimates of food system GHG emissions



Food system emissions : 21–37% of total anthropogenic emissions" (IPCC SRCCL, 2019; Rosenzweig 2020)

Vermeulen et al. (2012):

"Food systems contribute 19%–29% of global anthropogenic greenhouse gas (GHG) emissions"

Method: literature review for different stages

Scale: average estimate (no linked to specific scale) along food chain

Poore and Nemecek (2018):

"Today's food supply chain creates ~13.7 Gt of carbon dioxide equivalents (CO₂eq), 26% of anthropogenic GHG emissions"

Method: compilation of available LCA studies

Scale: global average values per product group along food supply chain

Bajzelj et al. (2013):

Food emissions estimates as 15.3 Tg CO₂eq (30.2% of 50.1 Tg CO₂eq total anthropogenic emissions).

Method: Mapping sectors to services

Scale: global representative values

Why EDGAR-FOOD?

It responds to the lack of detailed data for many countries by providing sectoral contributions to food-system emissions that are essential for the design of effective mitigation actions.



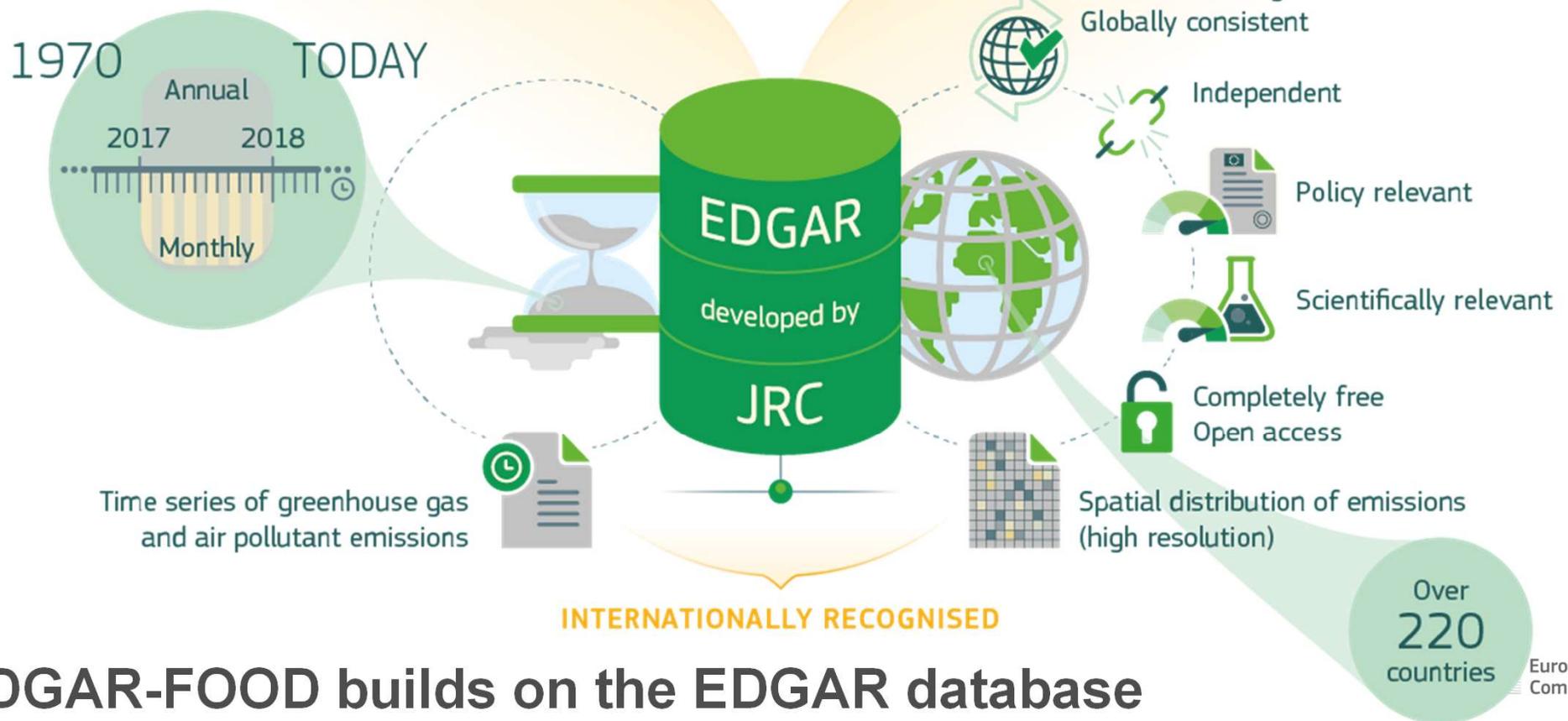
- complete and consistent database in time (1990-2015) and space (all countries) of GHG emissions from the global food system
- All food system stages: from production to consumption and waste, including processing, transport and packaging

It helps in monitoring global food system emissions, as part of integrated initiatives such as the European Commission's Farm to Fork strategy.

The Emissions Database for Global Atmospheric Research (EDGAR)

ACCOUNTABILITY

EXCELLENCE



EDGAR-FOOD builds on the EDGAR database

EDGAR-FOOD methodology



+



FAOSTAT Emission Shares
(LULUC)



$$E_{i,c,t}^{Food} = \sum_{s=1}^n E_{i,s,c,t} \times \text{SFS}_{s,c,t}$$

Sectoral Food-system Share (SFS):

- Food crops and livestock (SFS=1)
- IEA heat and electricity consumption
- fertilisers for food crops (FAO, USDA, etc.)
- world steel association
- global Aluminum flow model..many others...

By country/region, over time

Food system stages



IPCC sectors:

- 1) Landbased
- 2) Energy
- 3) Industry
- 4) Waste

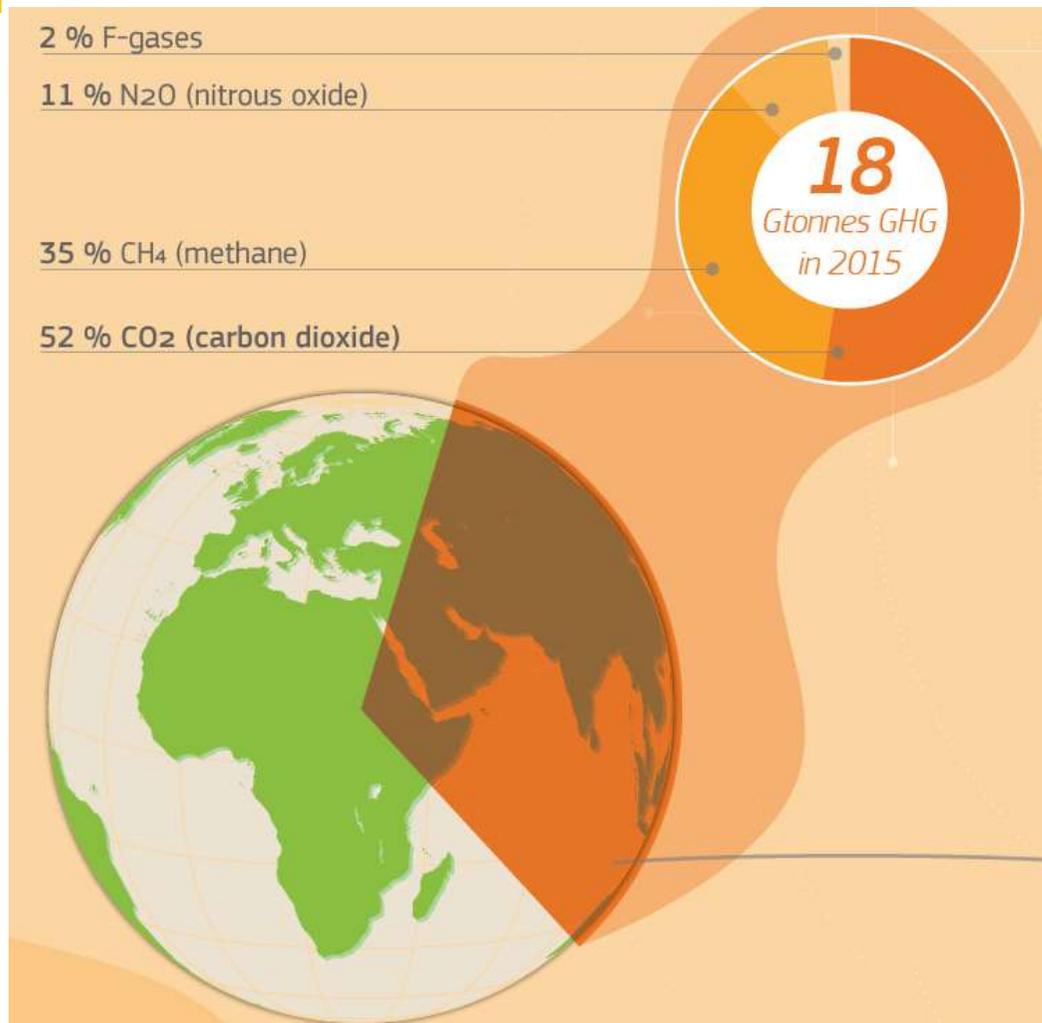
Raw materials, inputs for primary food production, provision of primary energy are assigned to each stage.

Food systems stages:

- 1) Land Use, Land Use Change (LULUC)
- 2) Production: primary production of food commodities
- 3) Processing: food processing
- 4) Consumption
- 5) Distribution: Packaging, Transport, Retail
- 6) End of life: waste

Detailed categories

A third of global GHG emissions come from food systems (2015)



Share of GHG emissions from food systems:

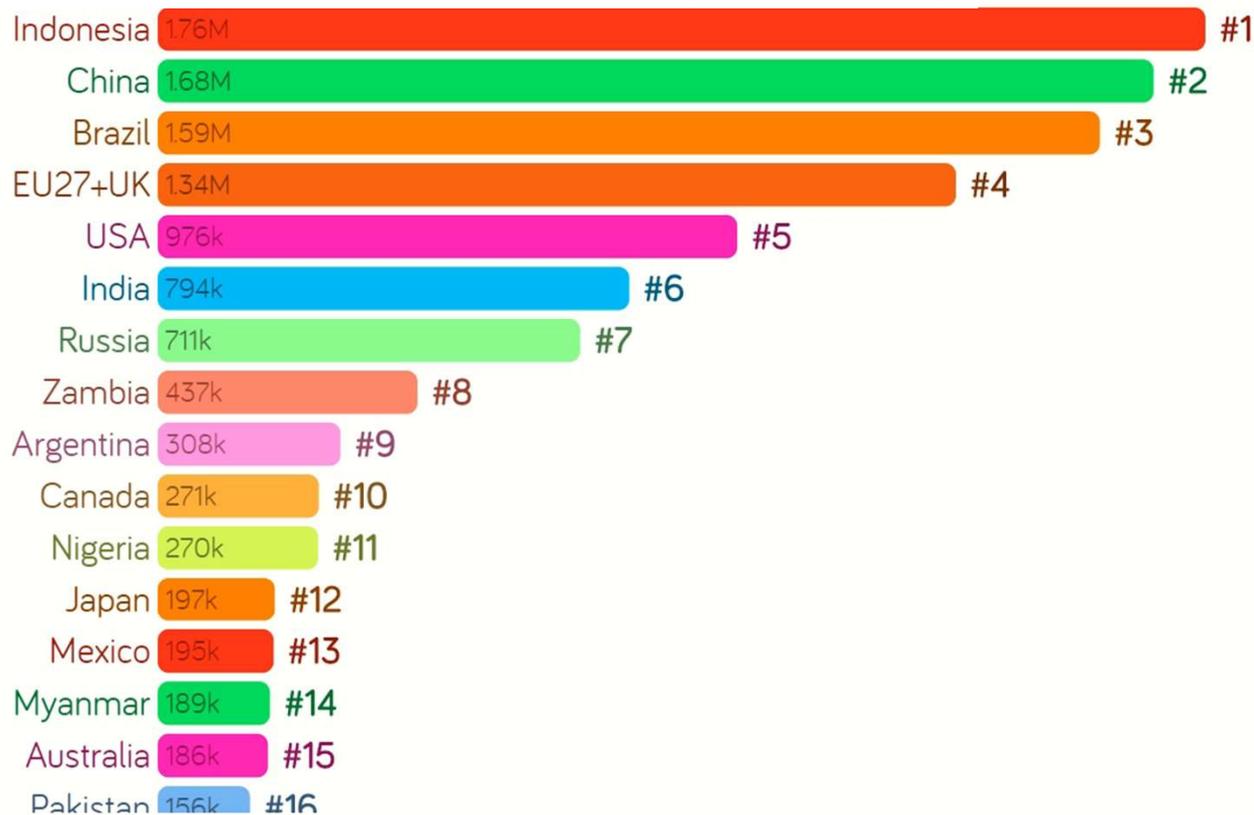
EU: 30% (7% of global food emissions)

Developing countries: 39% (73% of global food emissions)

Industrialised countries: 24% (27% of global food emissions)

Top emitting economies

GHG emissions from food (kt CO₂eq)

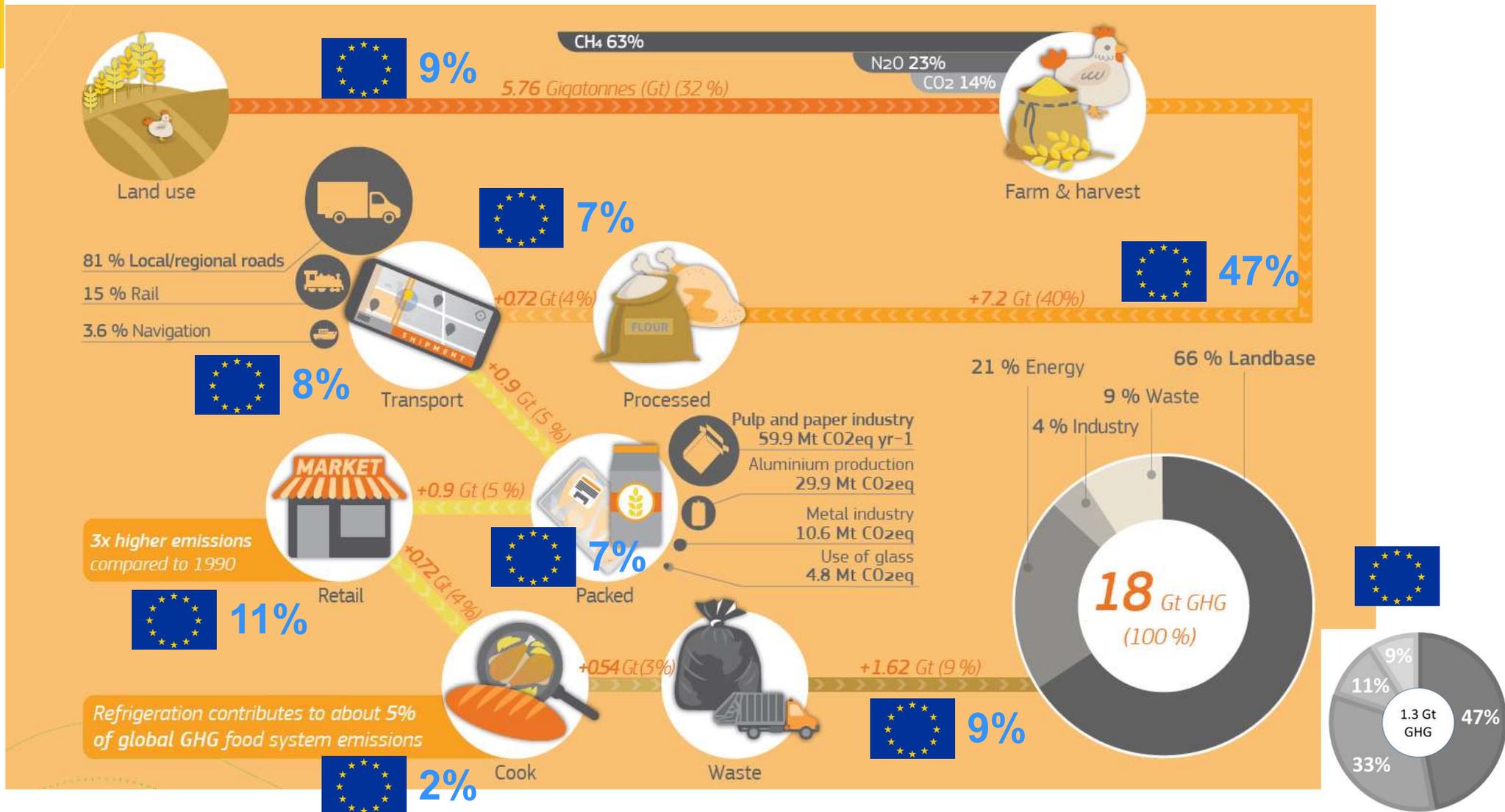


Top 6 emitting economies in 2015:

~ 50% of world GHG emissions from food systems



From farming to disposal

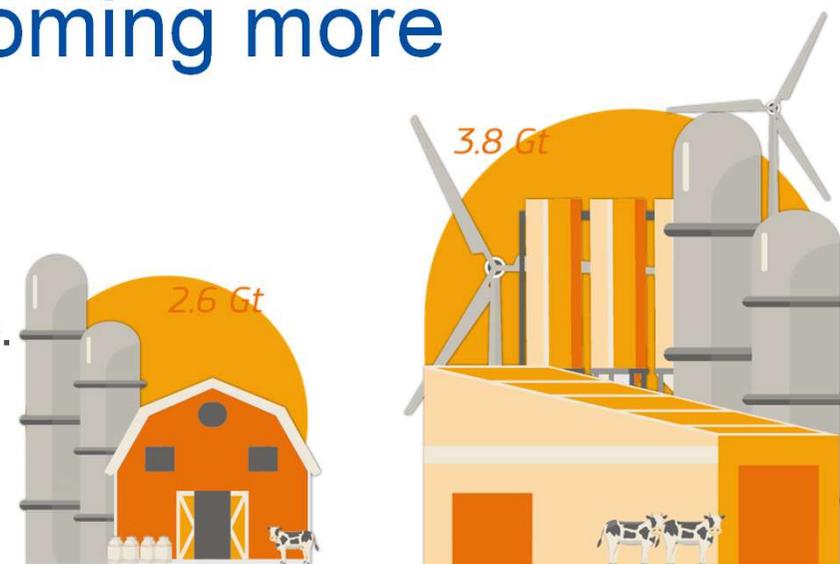


The global food system is becoming more energy intensive

Food systems require materials and energy for processing, packaging, transporting and storage.



A third of GHG food system emissions comes from energy related activities.



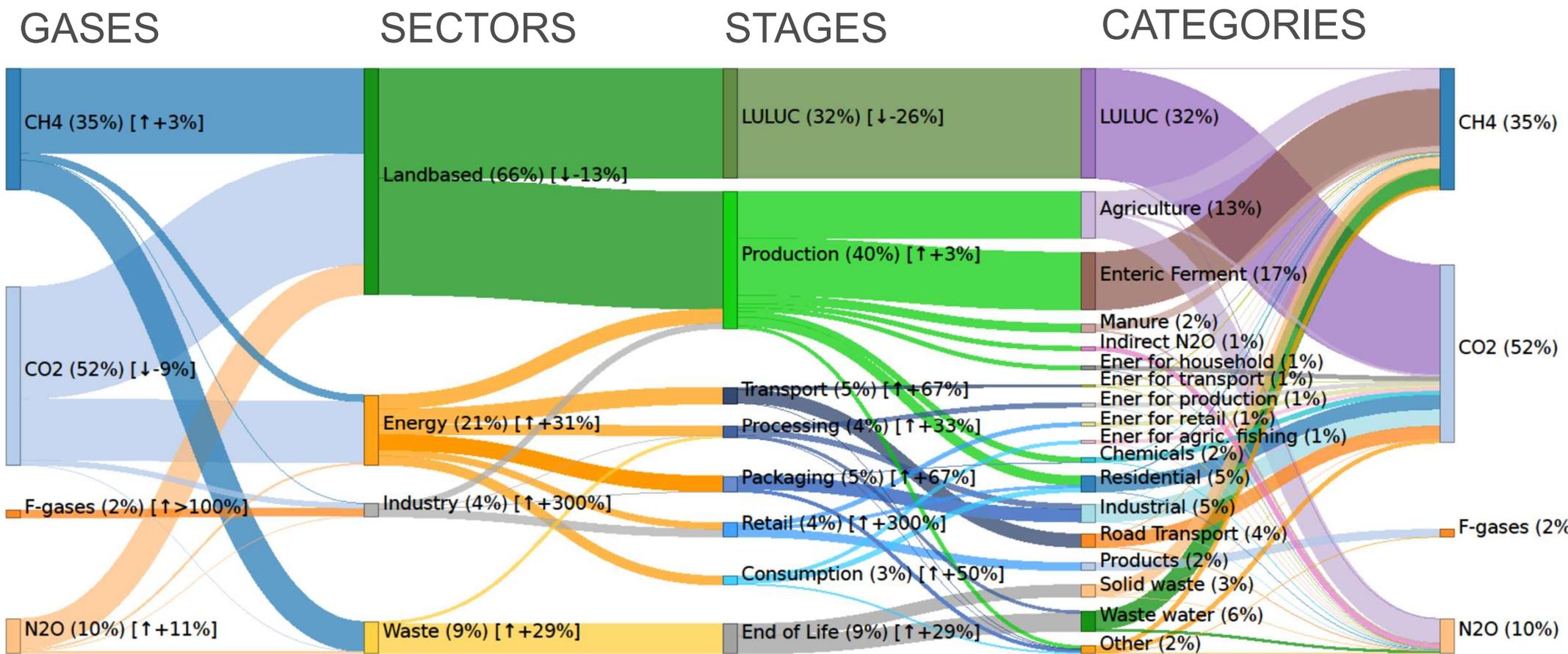
Energy use in agriculture: +15% compared to 1990



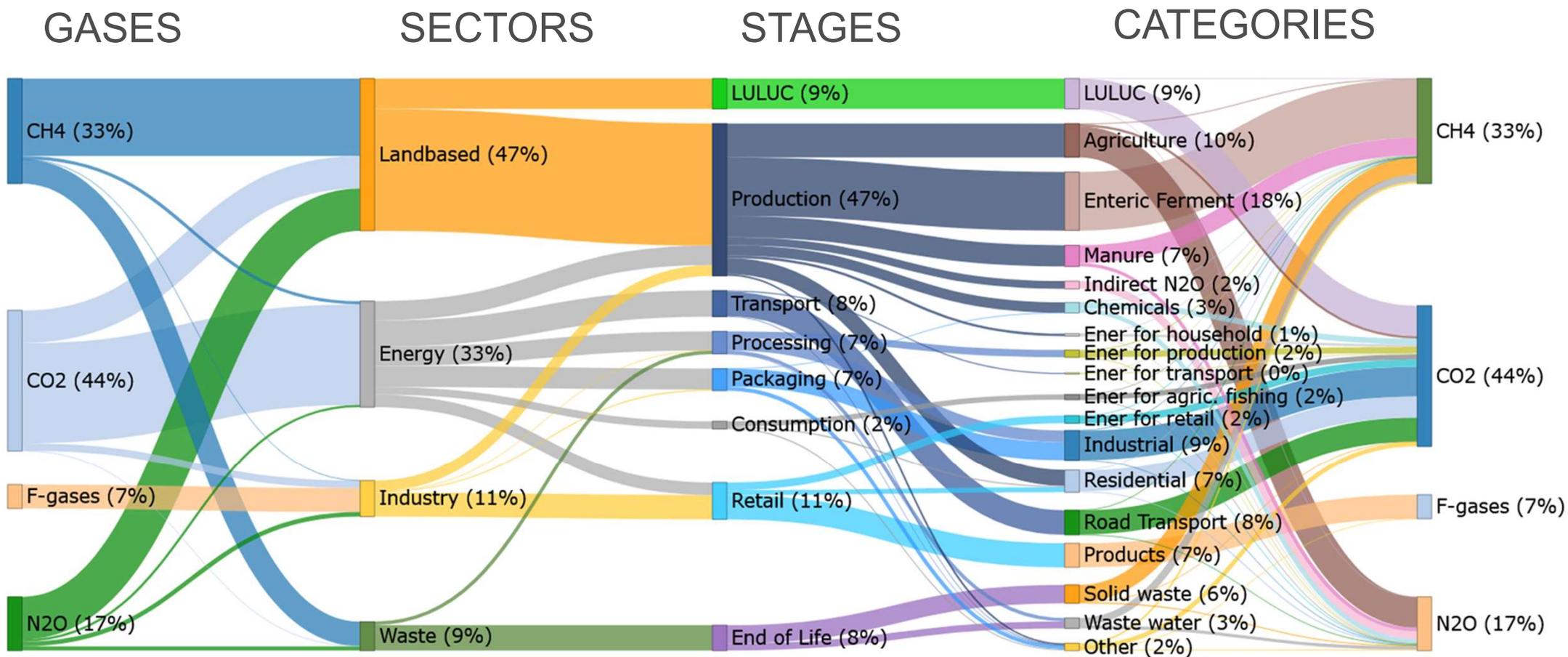
DEVELOPING REGIONS: +50% (more mechanised agriculture leading to higher use of fertilisers and pesticides).

INDUSTRIALISED COUNTRIES: -28%, lower energy use due to agronomic progress and environmental restrictions 
more efficient use of fertilisers and increased efficiencies in livestock production.

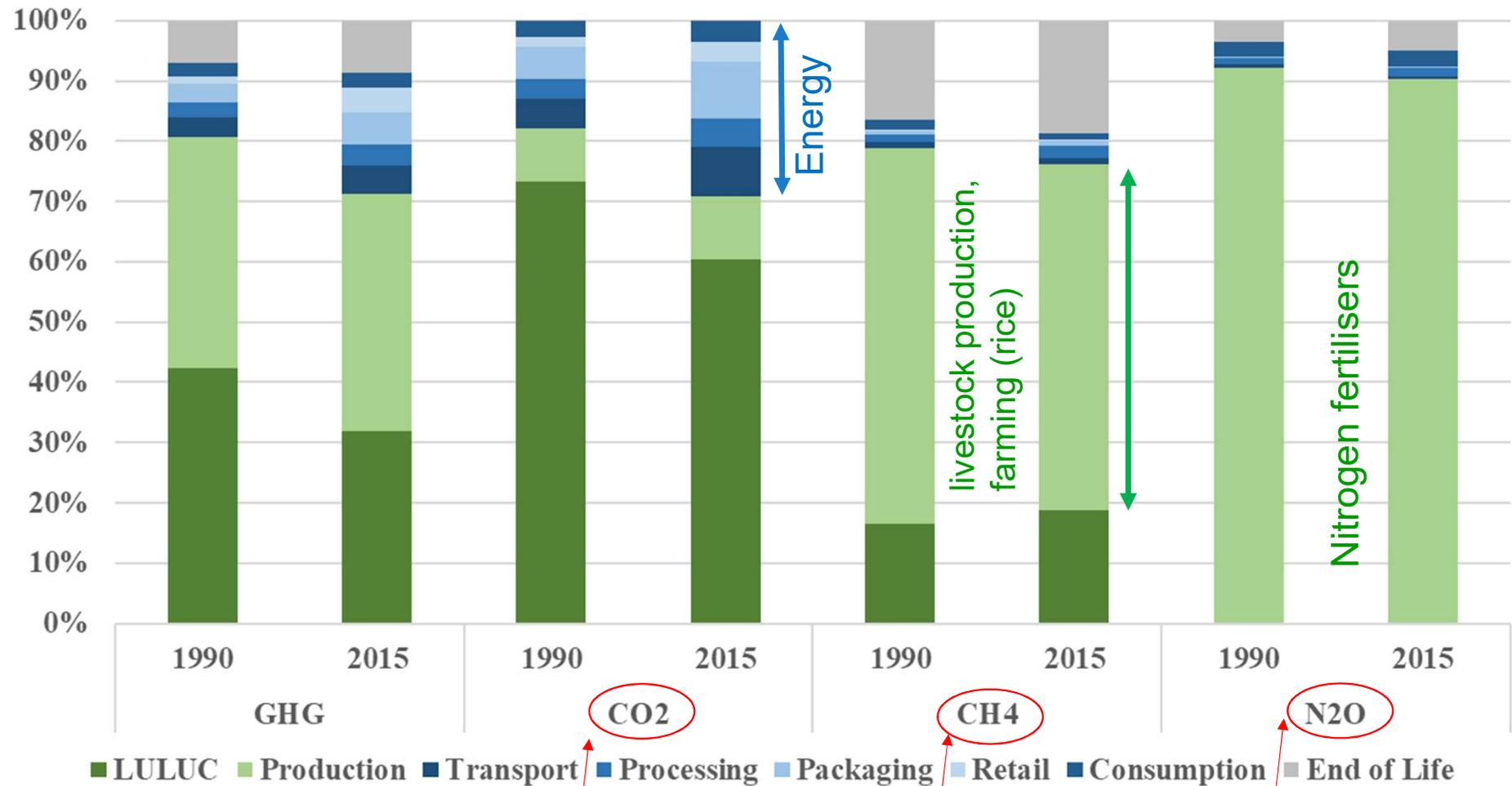
Interlinkages between food-system GHG emission components (global, 2015)



Interlinkages between food-system GHG emission components (EU, 2015)



Food system emissions by gas

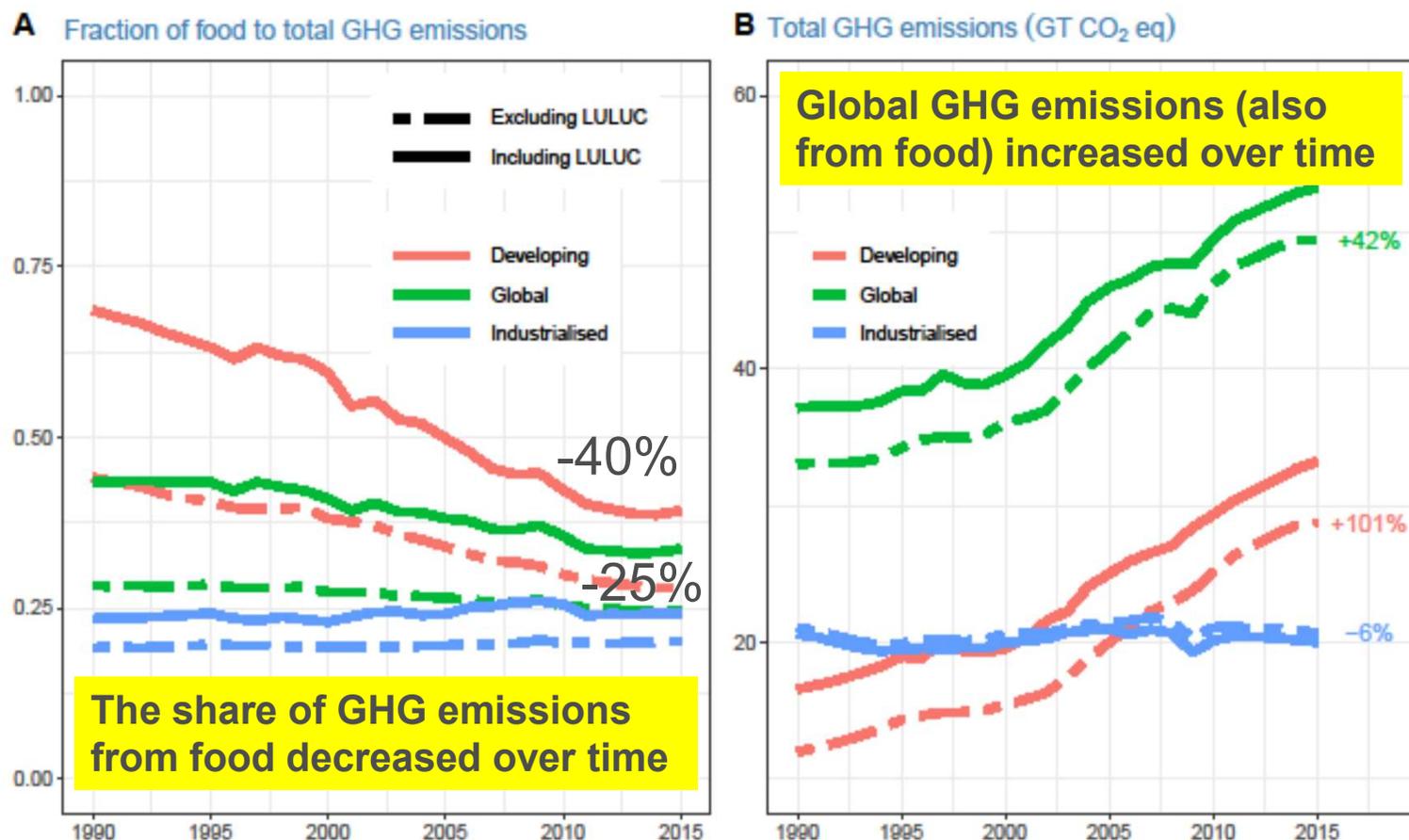


52% of global food emissions

35% of global food emissions

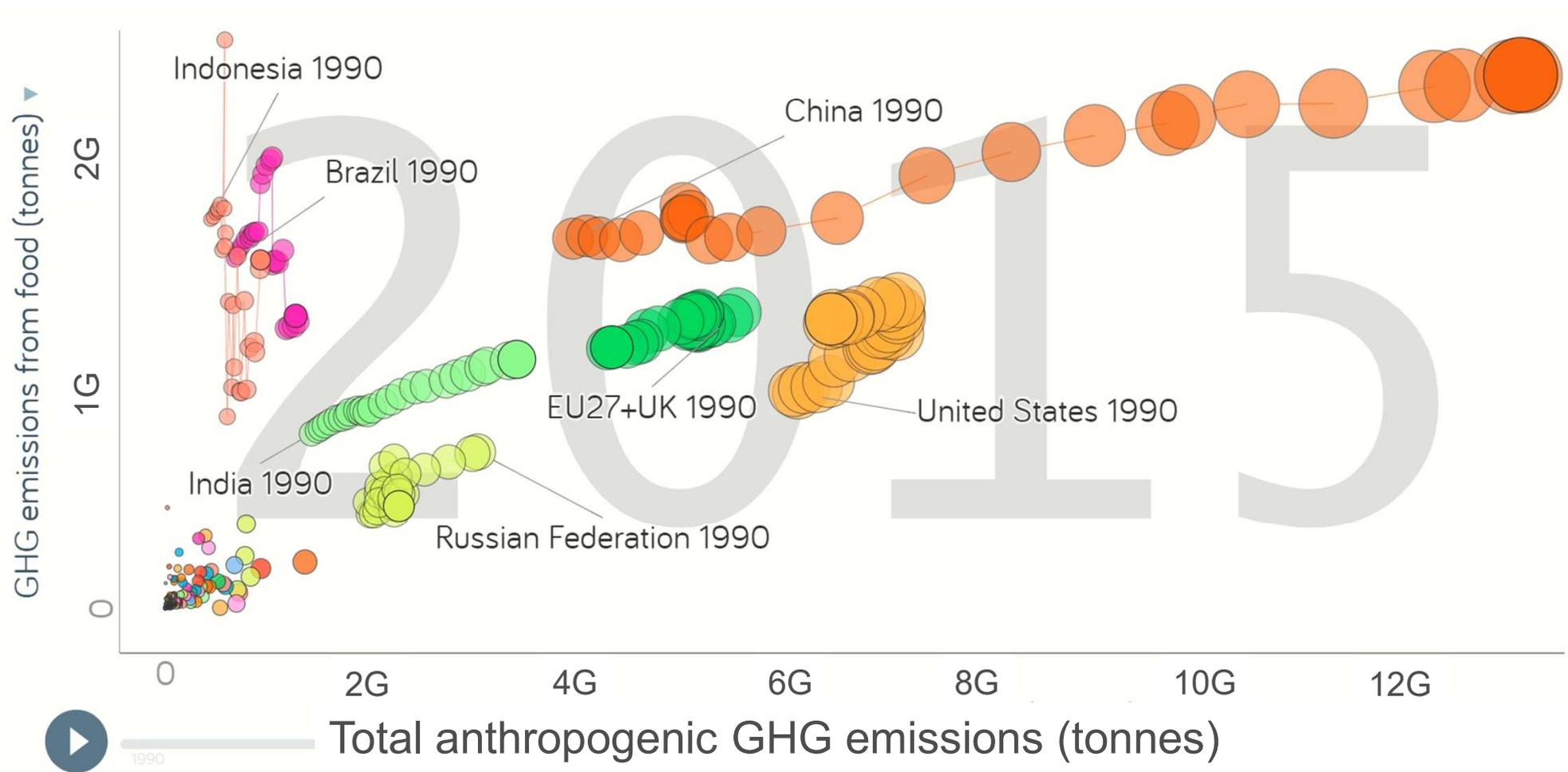
11%

GHG food emission intensity has decreased

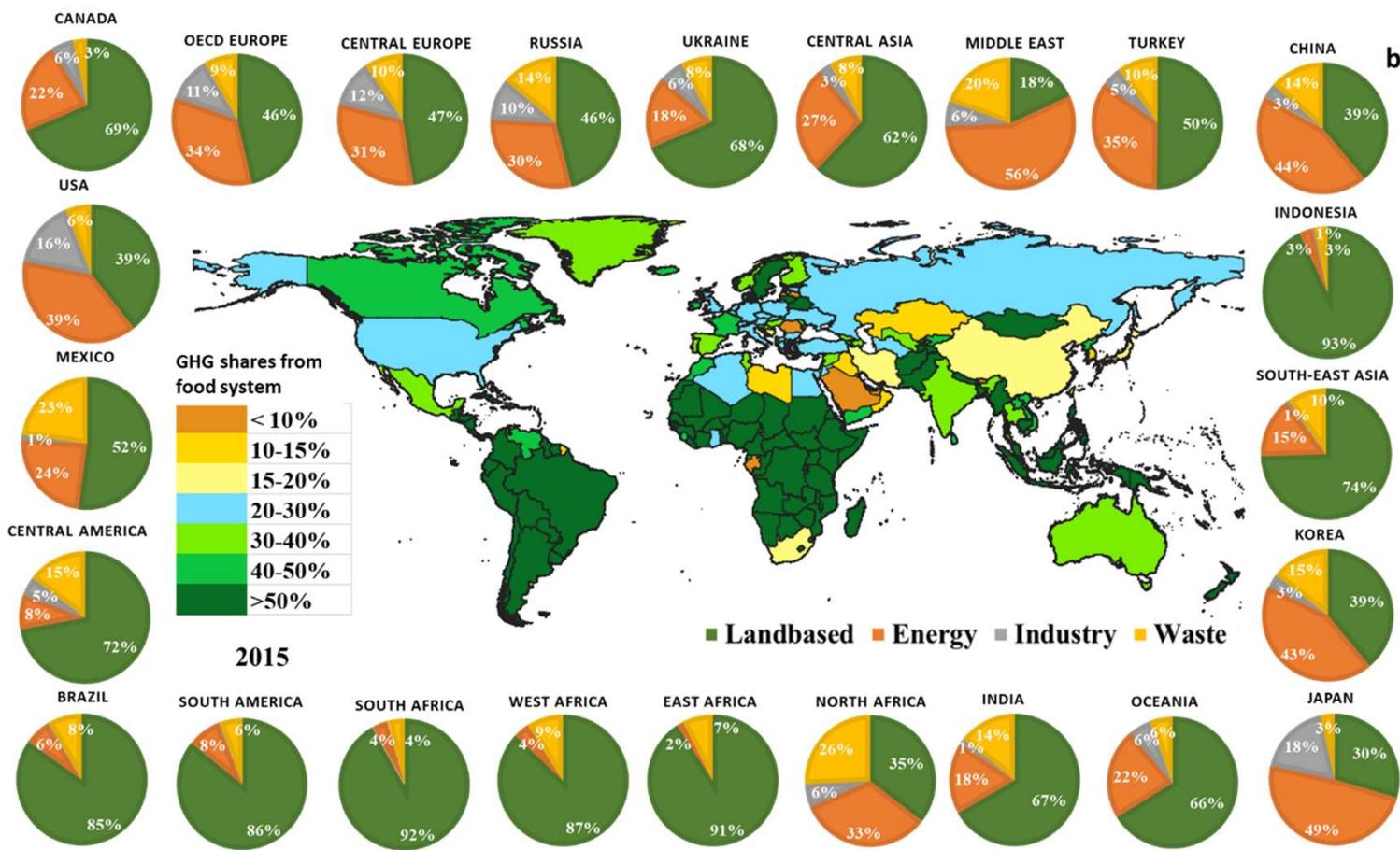


Global food production (taking cereals as proxy), increased by over 40%, indicating an overall decrease in the emission intensity of food.

Food vs total GHG emission for top emitters



Regional shares of GHG emissions from food systems (2015)

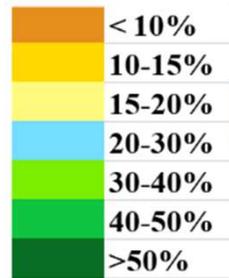


High shares of food emissions:

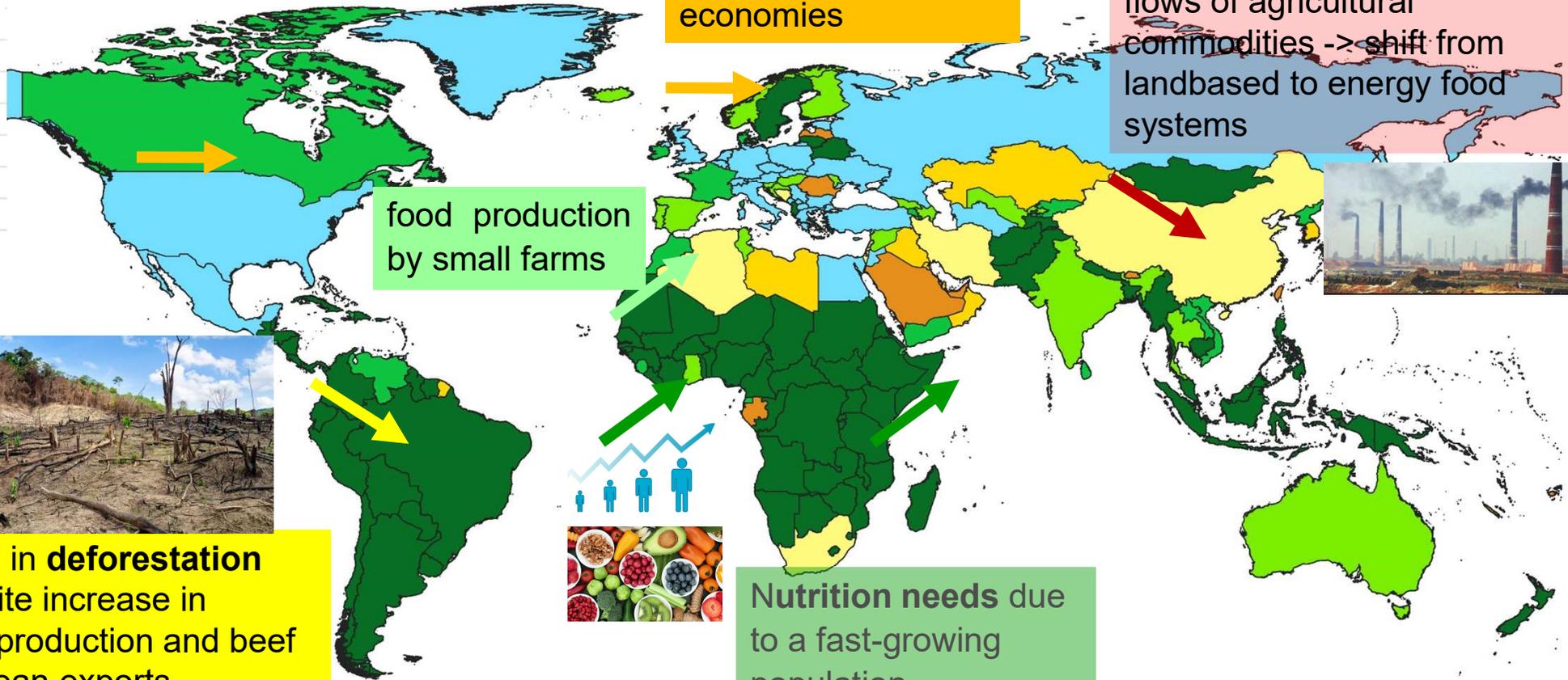
- 1) low-income countries with small local industry and other economic sectors than agriculture (Africa, SE Asia)
- 2) important food exporting industry (Brazil, Argentina, Latin America)
- 3) high food-system emissions from LULUC (Brazil, Indonesia, Africa)

1990-2015 food system GHG emission share trends

GHG shares from food system



2015



Low shares for energy intensive economies

Industrialisation and trade flows of agricultural commodities -> shift from landbased to energy food systems

food production by small farms

Nutrition needs due to a fast-growing population

Decrease in deforestation rate despite increase in livestock production and beef and soybean exports



Per capita emissions from food systems

Global average per capita emissions:

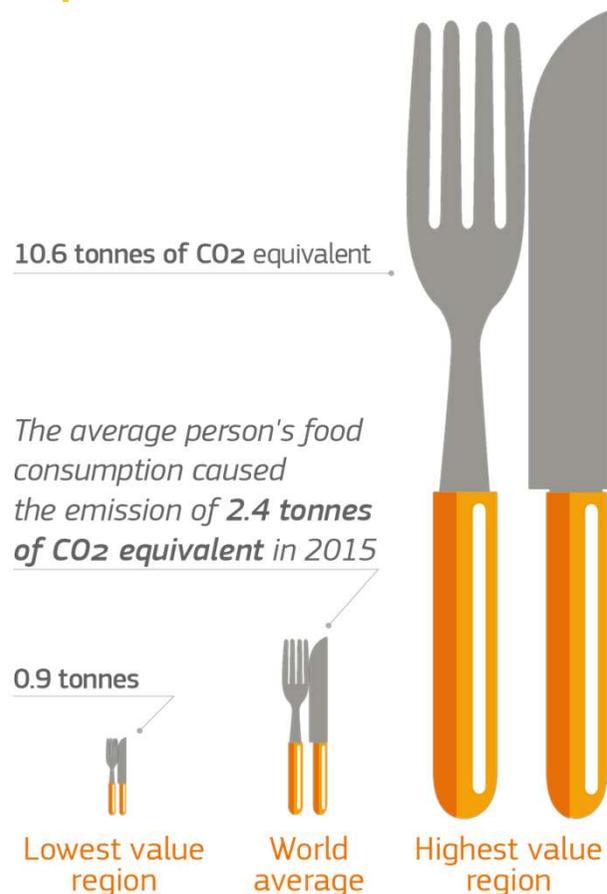
2.4 tCO₂eq/cap in 2015 (3 tCO₂eq/cap in 1990)

...but large regional differences....

Per capita emissions ≠ consumer GHG footprints

Per capita values reflect the structure of the countries' food system and economy → to benchmark national mitigation efforts to reduce GHG emissions from food.

Effective policies to transform food systems towards sustainability need to be comprehensive and provide adequate information to the economy and its consumers (focus on food production and food consumption)



Regional perspectives in 2015

Europe

Food share: 30% (7% of global food)

Per capita: 2.4 tCO₂eq/cap/yr

Russia

Food share: 20% (7.4% of globe)

Per capita: 2.2 tCO₂eq/cap/yr

North America

Food share: 25% (9.1% of global food)

Per capita: 5.2 tCO₂eq/cap/yr

China

Food share: 19% (13.5% of globe)

Per capita: 1.7 tCO₂eq/cap/yr

Latin America

Food share: 66% (17% of global food)

Per capita: 4.7 tCO₂eq/cap/yr

India

Food share: 38% (6.3% of globe)

Per capita: 0.9 tCO₂eq/cap/yr

Africa

Food share: 67% (17% of global food)

Per capita: 2.8 tCO₂eq/cap/yr

Conclusions

- Globally: **decoupling of population growth and food system emissions**
- Regional differences: areas with rapidly increasing emissions due to domestic demand for either food or export.
- Food system GHG emissions are not dominated by CO₂ emissions from fossil fuels (differently from total GHG emissions): relevance of **land-based emissions requiring dedicated mitigation options**.
- However, food emissions are increasingly determined by energy use, industrial activities and waste management → ambitious reductions of food system GHG emission requires also energy efficiency and decarbonisation policies.

EDGAR-FOOD provides a picture of how an evolving world food system has responded to the evolution of world population in the last 25 years



Land use



2.6 Gt



3.8 Gt



Diet Welfare Technology

How can EDGAR-FOOD help?



- **Broad geographical, temporal and thematic detail** of national GHG emissions from food systems -> describe how the global food system developed.
- **Detailed and consistent emissions for the entire food system** -> Detailed and consistent food system emissions since 1990 in the context of macro drivers
- **monitoring** global food system emissions (Farm to Fork strategy).
- Provide evidence to the discussion on sustainable consumption patterns

EDGAR-FOOD: the first global inventory of GHG emissions from food systems



Food systems are responsible for a third of global anthropogenic GHG emissions

M. Crippa¹, E. Solazzo¹, D. Guizzardi¹, F. Monforti-Ferrario¹, F. N. Tubiello^{1,2} and A. Leip^{1,3*}

We have developed a new global food emissions database (EDGAR-FOOD) estimating greenhouse gas (GHG; CO₂, CH₄, N₂O, fluorinated gases) emissions for the years 1990–2015, building on the Emissions Database of Global Atmospheric Research (EDGAR), complemented with land use/land-use change emissions from the FAOSTAT emissions database. EDGAR-FOOD provides a complete and consistent database in time and space of GHG emissions from the global food system, from production to consumption, including processing, transport and packaging. It responds to the lack of detailed data for many countries by providing sectoral contributions to food-system emissions that are essential for the design of effective mitigation actions. In 2015, food-system emissions amounted to 18 Gt CO₂ equivalent per year globally, representing 34% of total GHG emissions. The largest contribution came from agriculture and land use/land-use change activities (73%), with the remaining were from supply chain activities: retail, transport, consumption, fuel production, waste management, industrial processes and packaging. Temporal trends and regional contributions of GHG emissions from the food system are also discussed.

Food needs to be farmed, harvested or caught, transported, processed, packaged, distributed and cooked, and the residuals disposed of. Each of these steps causes emissions of anthropogenic greenhouse gases (GHGs) and requires energy. Inputs such as fertilizers or energy need to be produced and made available at the right time and location^{1–4} with additional associated GHG emissions.

Major datasets of GHG inventories—including those with country coverage (National Inventory Reporting under the United Nations Framework Convention on Climate Change (UNFCCC)), regional or global coverage (for example, the Emissions Database of Global Atmospheric Research (EDGAR, <https://edgar.jrc.ec.europa.eu/>), GAINS (<https://maas.ac.il/web/home/research/researchPrograms/gains.html>) and FAOSTAT (<http://www.fao.org/faostat/en/#data>))—provide detailed temporal and sectoral evolution of total GHG emissions. Yet, emissions from the food systems are scattered across many different source categories (Supplementary Fig. 1). Global estimates of the share of emissions associated with agriculture, which includes farm gas production and associated land use, have been produced⁵, and more recently emission estimates from the various stages of the life cycles of food products have also been made available^{6–8}. Another recent estimate of global food-system emissions has been provided by the Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change and Land⁹, attributing between 10.8 and 19.1 Gt CO₂-equivalent (CO₂e) emissions per year to the food system globally, corresponding to 21% to 37% of overall anthropogenic emissions^{10,11}. Other studies report good agreement between ‘top down’ and ‘bottom up’ methods^{12,13} for Europe. The review of available resources for emissions from food systems shows how, overall, available data are based on detailed product-specific life cycle assessment studies^{14,15} or are using aggregated global data^{16–18}. So far, however, studies encompassing global coverage of the whole food-system at country level are missing and, consequently, the total emissions and the total share of those emissions associated with food systems are largely unknown.

The global database of GHG emissions (CO₂, methane (CH₄), N₂O, fluorinated gases (F-gases)) from food systems (EDGAR-FOOD) developed in this Article aims to fill this gap by using a consistent methodological framework. EDGAR-FOOD has been developed to aid the understanding of the activities underlying energy demand and use, as well as agriculture and land-use change, and emissions associated with the production, distribution, consumption and disposal of food through the various stages and sectors of the composite global food system. These data were complemented with data from the FAOSTAT database on GHG emissions from land use related to agriculture¹⁹. EDGAR-FOOD represents the first database consistently covering each stage of the food chain for all countries with yearly frequency for the period 1990–2015.

Emissions from the food system

A third of global GHG emissions comes from the food system. Our estimate of the contribution of food systems to total anthropogenic GHG emissions was 34% (range 25% to 42%) for the year 2015. Global GHG emissions from the food system were 18 Gt CO₂e yr⁻¹ (95% confidence interval (CI) 14–22 Gt CO₂e yr⁻¹) in 2015, with 27% (or 4.9 (95% CI 3.7 to 6.4) Gt CO₂e yr⁻¹) emitted by industrialized countries (country definitions are regional groupings and are provided in Supplementary Table 2), and the remaining 73% (or 13 (95% CI 10 to 16) Gt CO₂e yr⁻¹) emitted by developing countries (including China) (Fig. 1). In 2015, 71% of global GHG emissions from the food system was associated with the land-based sector, defined herein as agriculture and associated land use and land-use change activities (the latter will be referred to as LULUC). In industrialized countries, the contribution of the downstream energy-related sectors (53%), which includes industry and waste, was larger than the land-based sector, while in developing countries agriculture and LULUC were the dominant fraction (73%) (Fig. 1).

In 2015, six top emitting economies (the term ‘economies’ is used to allow the European Union to be considered as a single entity) with individual contributions larger than 6% to the global total GHG

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NATURE FOOD | www.nature.com/naturefood

Media attention

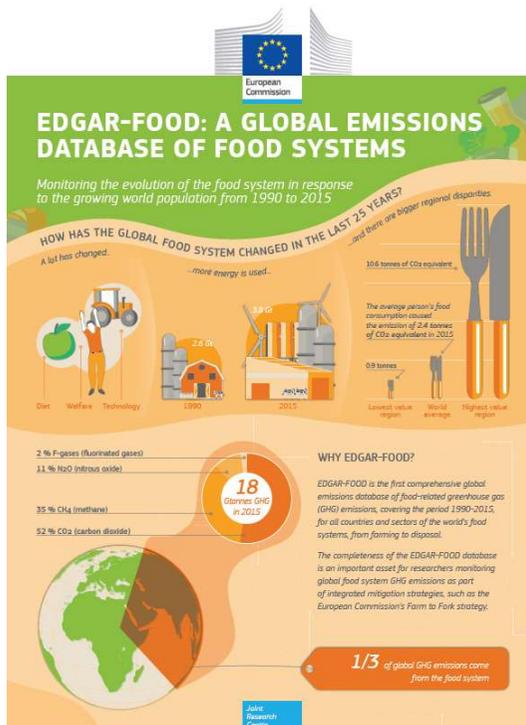
....many others...



<https://www.nature.com/articles/s43016-021-00225-9>

The way forward

Start informing activities ...towards policy support



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Sixth Assessment Report

The Sixth Assessment Report is underway.

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Farm to Fork Strategy

For a fair, healthy and environmentally-friendly food system

Extension of EDGAR-FOOD to air pollutant emissions from food systems

Thank you



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