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FAOSTAT ANALYTICAL BRIEF 65

Greenhouse gas emissions from pre- and post-agricultural production processes

Global, regional and country trends, 1990–2020

>> FAO Statistics Division

HIGHLIGHTS

- → **FAOSTAT is launching a new statistical domain dedicated to greenhouse gas emissions from pre- and post-agricultural production activities in agrifood systems to better capture the environmental impact of agrifood systems.**
- → **Overall, pre- and post-agricultural production emissions reached 5.5 billion tonnes of carbon dioxide equivalent (Gt CO_2eq) worldwide in 2020, which was more than 10 percent of the total anthropogenic emissions and over one-third of the total agrifood system emissions.**
- → **The global pre- and post-agricultural production emissions kept increasing between 1990 and 2020, although at a gradually slowing pace: 31 percent (from 1990 to 2000), 29 percent (from 2000 to 2010) and 14 percent (from 2010 to 2020).**
- → **The COVID-19 pandemic had a modest impact on the overall pre- and post-agricultural production emissions (which remained stable in 2020) but a pronounced impact on some components: food transport (-9 percent), fertilizers manufacturing (+8 percent), food packaging (+6 percent) and household consumption (+3 percent).**
- → **Global food-related fluorinated gas emissions have sharply increased, with the strongest increase between 2010 and 2020 seen in Asia (+157 percent in CO_2eq), Africa (+111 percent) and the Americas (+77 percent).**
- → **The countries with the largest pre- and post-agricultural production emissions in 2020 were China (1.45 Gt CO_2eq), India (0.52 Gt CO_2eq), the United States of America (0.47 Gt CO_2eq), the Russian Federation (0.23 Gt CO_2eq) and Brazil (0.17 Gt CO_2eq), with large variations in per capita emissions, from 371 kg CO_2eq/capita in India to 1 604 kg CO_2eq/capita in the Russian Federation.**

FAOSTAT GREENHOUSE GAS EMISSIONS FROM PRE- AND POST-AGRICULTURAL PRODUCTION

BACKGROUND

Agrifood systems account for one-third of total anthropogenic greenhouse gas (GHG) emissions (Crippa *et al.*, 2021; Tubiello *et al.*, 2021), and pre- and post-agricultural production (hereafter referred to as pre- and post-production) activities represent just over 33 percent (5.5 Gt CO_2eq) of agrifood systems emissions. These activities cover activities after the farm gate (food processing, food packaging, food transport, food retail, food household consumption, agrifood systems waste disposal), and before the

fam gate (fertilizers manufacturing, pesticides manufacturing, generation of electricity used on farm, generation of heat used on farm).

This analytical brief focuses on a new FAOSTAT domain dedicated to pre- and post-production emissions. Data already published in FAOSTAT in previous years, and previously disseminated in other domains, are now organized in the pre- and post-production domain, including information on both emissions and the underlying activity data.

The new domain also brings along significant updates compared to the data previously shown in FAOSTAT:

- energy use activity data (terajoules of coal, electricity, heat, petroleum products, and natural gas consumed by country and region across pre- and post-production activities),
- a new dataset on emissions from manufacturing of pesticides (previously not available),
- updated country- and year-specific grid emission factors for heat and electricity,
- an improved methodology to complete missing activity data in the time series,
- an improved methodology to estimate emissions from i) household food emissions, ii) domestic transport, and iii) fluorinated gas emissions originating from food processing, transport, retail and from food-related household activities,
- a new dataset on emissions from generation of heat used in agriculture, and
- updated energy statistics for 2020.

Statistics on the underlying activity data and emissions are disseminated in FAOSTAT at the country, regional and global level, covering 194 FAO Members and 30 territories for the period 1990–2020, and expressed in both single component gases – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (F-gases) – and their cumulative carbon dioxide equivalents (CO_2eq). This analysis focuses on results relative to the period 2000–2020.

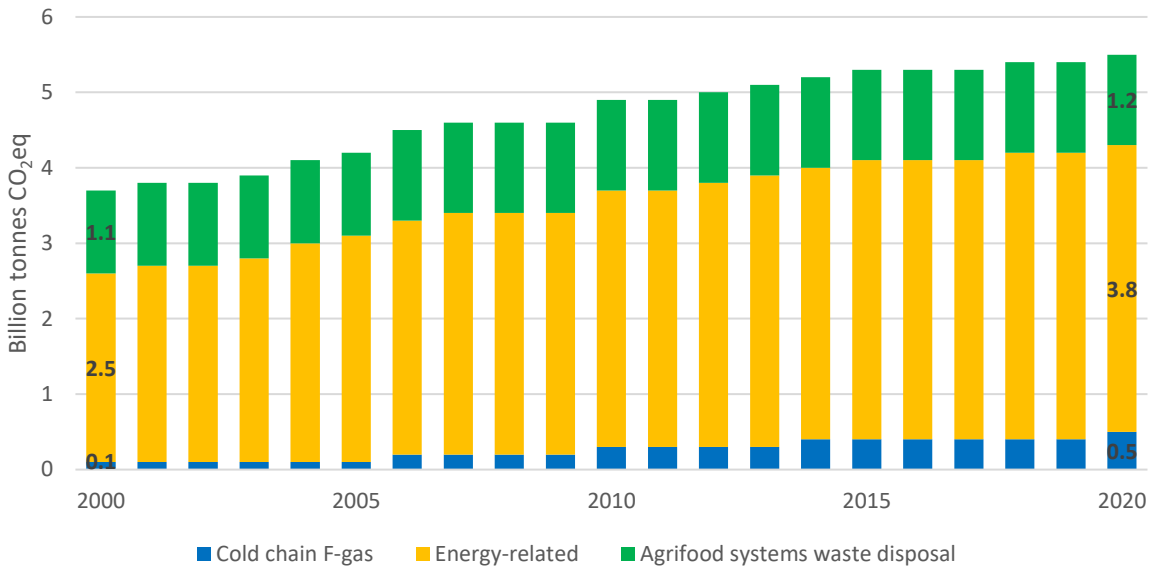
This work aims in to inform policymaking and mitigation strategies to address climate change effectively. By providing a comprehensive and updated dataset on pre- and post-production emissions, researchers and decision-makers can better understand the interconnections across agrifood system activities and target high priority areas for interventions.

GLOBAL

In 2020, global annual GHG emissions from pre- and post-production activities reached 5.5 Gt CO_2eq, roughly the same as in 2019, although there were important changes in the components that reflect a well-documented reduction in certain economic activities due to the COVID-19 pandemic. The global emissions were nonetheless 49 percent higher than in 2000 (3.8 Gt CO_2eq) and 13 percent higher than in 2010. The share of pre- and post-production in total agrifood systems emissions in 2020 (34 percent) confirmed the steadily increasing trend since 2000 (25 percent), a consequence of pre- and post-production emissions (dominated by fossil fuels combustion for energy use and F-gas emissions) growing significantly quicker than other food-related activities.

Pre- and post-production emissions can be further grouped into i) emissions from energy use, ii) emissions from F-gases used in food cold chains and iii) emissions from agrifood system waste disposal. A closer look at these three groups highlights that while emissions from agrifood system waste disposal have not changed significantly over the last two decades (+11 percent), emissions from energy-related activities increased by 38 percent and emissions from F-gases increased five-fold.

Figure 1: Global pre- and post-production emissions by component



Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

With respect to individual greenhouse gases, CO_2 emissions increased by 48 percent between 2000 and 2020, from 2.4 Gt CO_2eq to 3.6 Gt CO_2eq, while the CO_2eq emissions of N_2O increased by 42 percent and those of CH_4 increased by 10 percent. F-gases had the most significant increase (+517 percent), from 0.07 Gt CO_2eq to 0.46 Gt CO_2eq, which reflects the accelerating expansion of food cold chains, especially in lower-income countries.

Table 1: Global pre- and post-production emissions by greenhouse gas

Greenhouse gas	2000		2020	
	Quantity (Gt CO_2eq)	Share in CO_2eq emissions (percent)	Quantity (Gt CO_2eq)	Share in CO_2eq emissions (percent)
Carbon dioxide	2.5	66	3.7	67
Methane	1.1	29	1.2	22
Nitrous oxide	0.1	3	0.5	8
F-gases	0.1	2	0.1	3

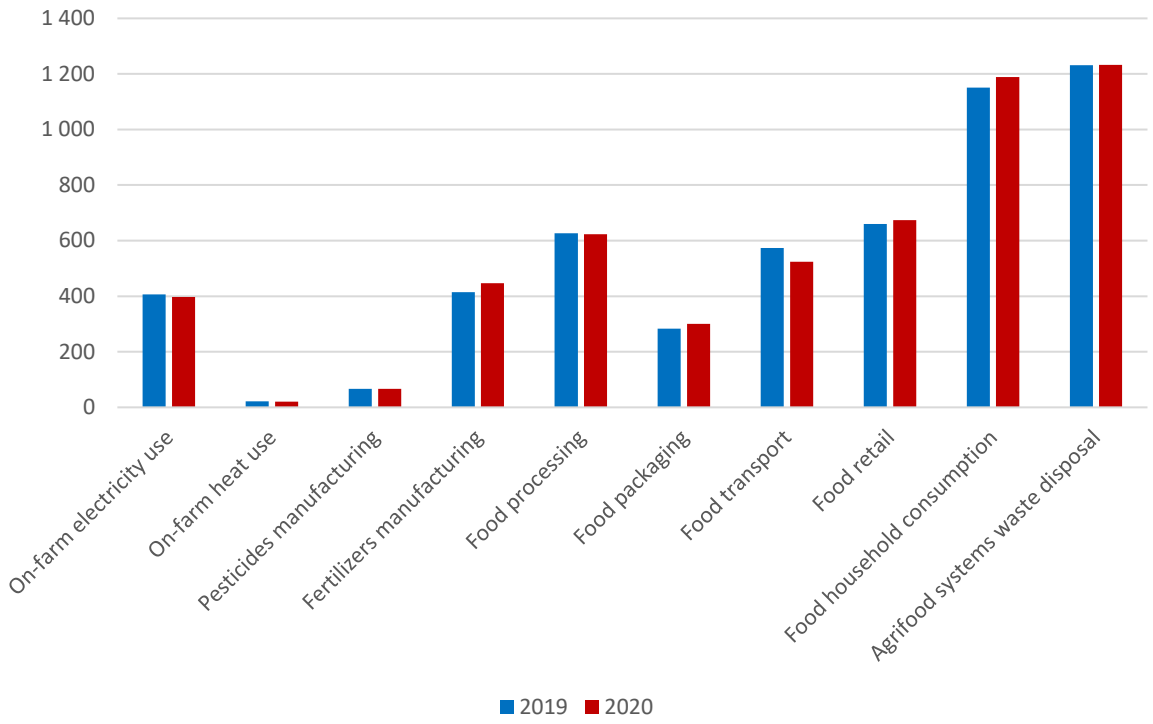
Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

A further breakdown by subcomponent highlights the relative importance of specific processes. Pre- and post-production emissions are dominated by activities related to food household consumption (1 201 Mt CO_2eq), followed by food retail (1 074 Mt CO_2eq) and food transport (873 Mt CO_2eq).

The COVID-19 pandemic in 2020 had different impacts on the emissions of pre- and post-production activities. Most notably, emissions from food transport were reduced by 86 Mt CO_2eq (-9 percent), while emissions from food household consumption accelerated their global increase by 38 Mt CO_2eq

(+3 percent). This is due to a general trend during the pandemics of reduced transport, and a trend to consume more food at home. 2020 also saw a significant increase of emissions from fertilizers manufacturing of 31 Mt CO_2eq (+8 percent).

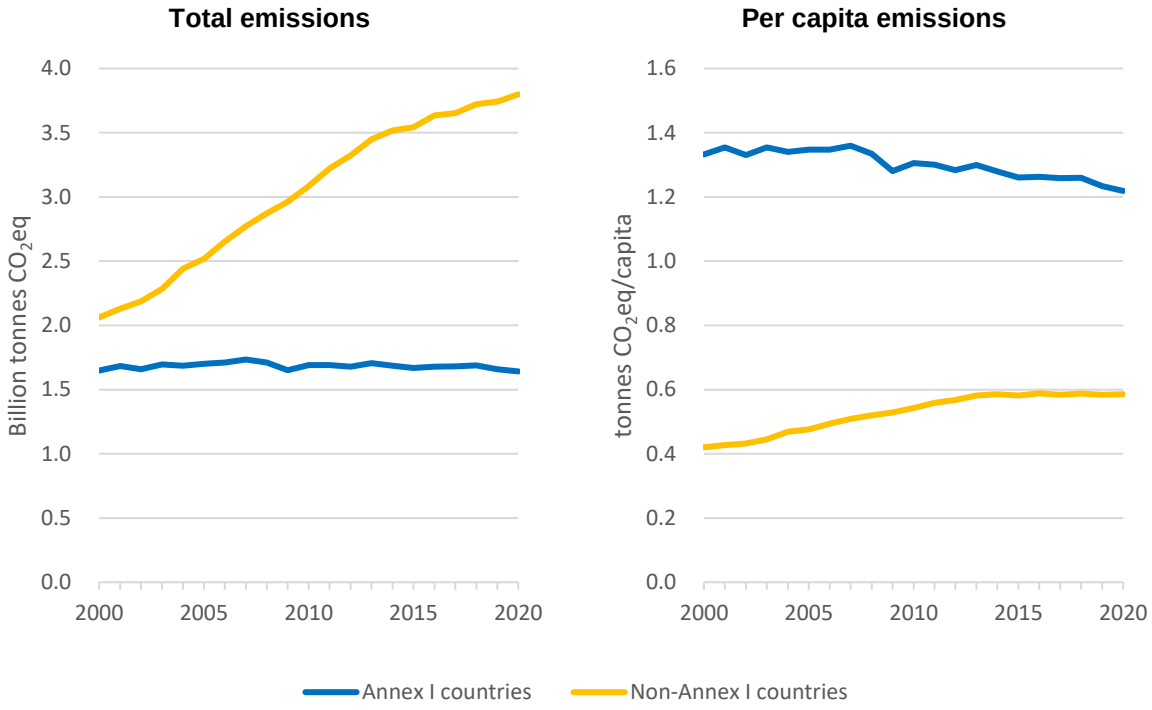
Figure 2: Change in global pre- and post-production emissions by component



Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

Pre- and post-production emissions are growing quicker in Non-Annex I parties reporting to the United Nations Framework Convention on Climate Change (UNFCCC) (83 percent) over the last two decades, while emissions from Annex I parties have remained stable. Nonetheless, emissions per capita are still significantly lower in Non-Annex I countries, which suggests these emissions could still grow significantly before reaching a plateau, under business-as-usual conditions (Figure 3).

Figure 3: Pre- and post-production emissions by region

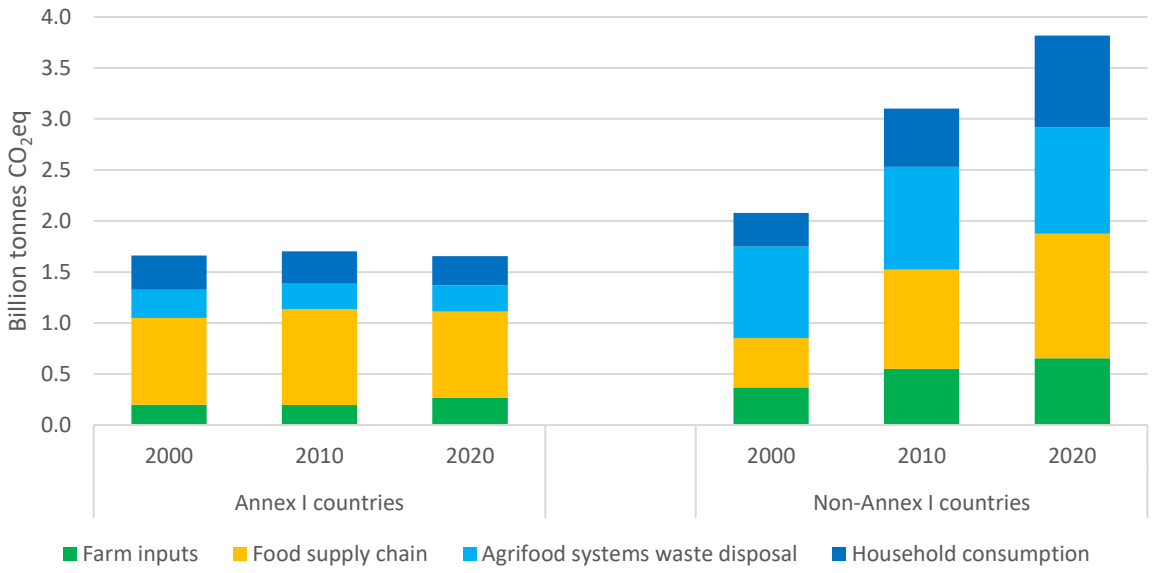


Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

One way to analyse pre- and post-production activities is to group them by activity groups, such as: farm inputs (i.e. pesticides and fertilizers manufacturing, generation of electricity and heat for on-farm use); food supply chain (i.e. food processing, packaging, transport and retail); household consumption (i.e. household food-related energy consumption); and agrifood systems waste disposal (i.e. domestic and industrial wastewater, solid food waste and incineration).

Such aggregations highlight that emissions in all categories have increased since 2000 in both Annex I and Non-Annex I countries, with the sharpest increase in household consumption and food supply chains in Non-Annex I countries (Figure 4). The sharpest increase could be seen in household consumption in Non-Annex I countries (+167 percent from 2000 to 2020), as households are shifting from traditional woodfuels (which are considered net-zero emissions in this analysis) to fossil fuels (e.g. liquefied petroleum gas [LPG]) and electricity for food preparation and consumption activities.

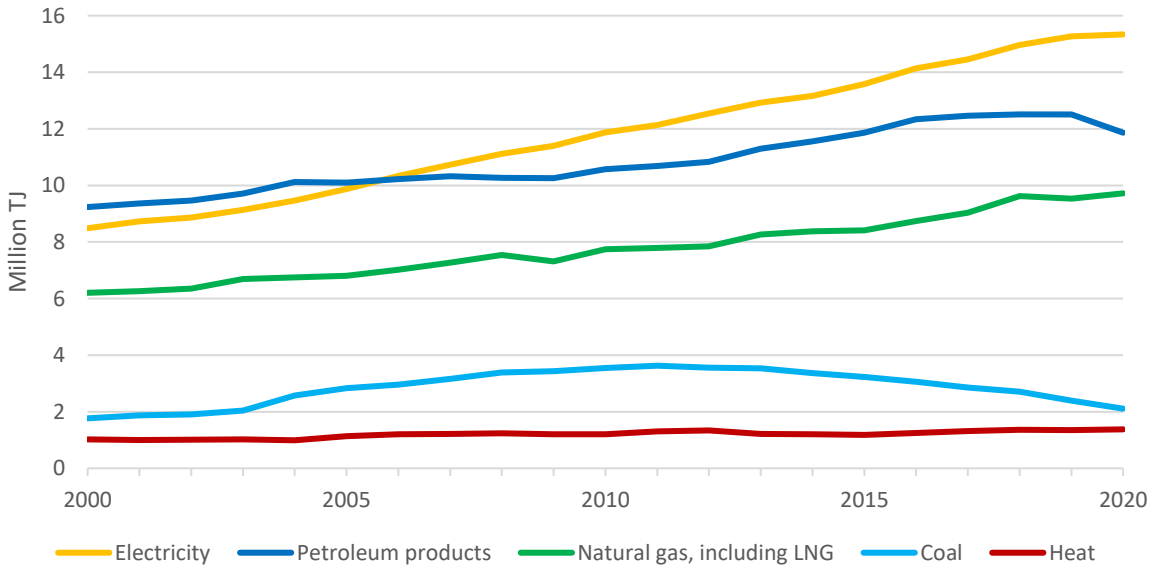
Figure 4: Pre- and post-production emissions by activity group and region



Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

While pre- and post-production emissions went up 47 percent since 2000, the corresponding energy consumption increased by 51 percent. Figure 5 shows that the consumption of electricity had the sharpest increase (80 percent between 2000 and 2020), followed by natural gas (57 percent), while coal remained relatively stable overall, suggesting a gradual shift towards cleaner, less CO_2-intensive fuels.

Figure 5: Pre- and post-production energy consumption by energy carrier

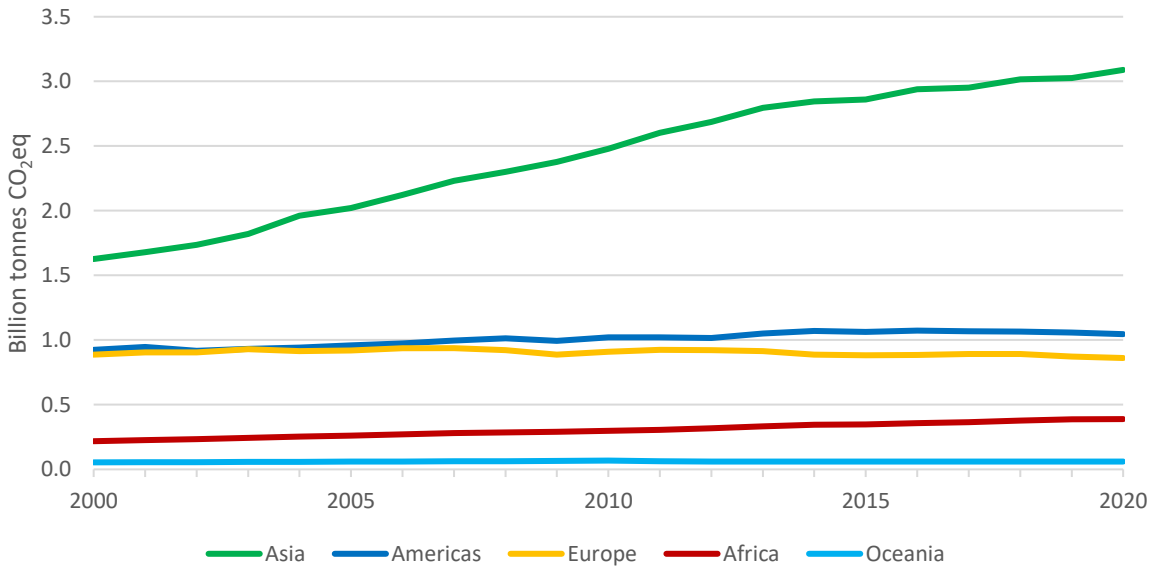


Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

REGIONAL

In 2020, total pre- and post-production emissions were the largest in Asia (3.09 Gt CO_2eq) and the Americas (1.05 Gt CO_2eq), mainly a reflection of area and population. Asia saw the largest growth in emissions, with an increase of 90 percent from 1.63 Gt CO_2eq to 3.09 Gt CO_2eq, likely due to rapid industrialization and population growth. Africa's emissions increased by 78 percent, from 0.22 Gt CO_2eq to 0.39 Gt CO_2eq, reflecting the region's expanding population and economic development. The Americas experienced a slower growth of 13 percent, from 0.93 Gt CO_2eq to 1.05 Gt CO_2eq, possibly due to a gradual shift towards cleaner energy sources. Oceania's emissions grew moderately by 11 percent, from 0.05 Gt CO_2eq to 0.06 Gt CO_2eq, likely driven by population growth and increasing energy demand. In contrast, Europe reduced its emissions by 3 percent, from 0.89 Gt CO_2eq to 0.86 Gt CO_2eq, likely due to widespread adoption of renewable energy and sustainable practices.

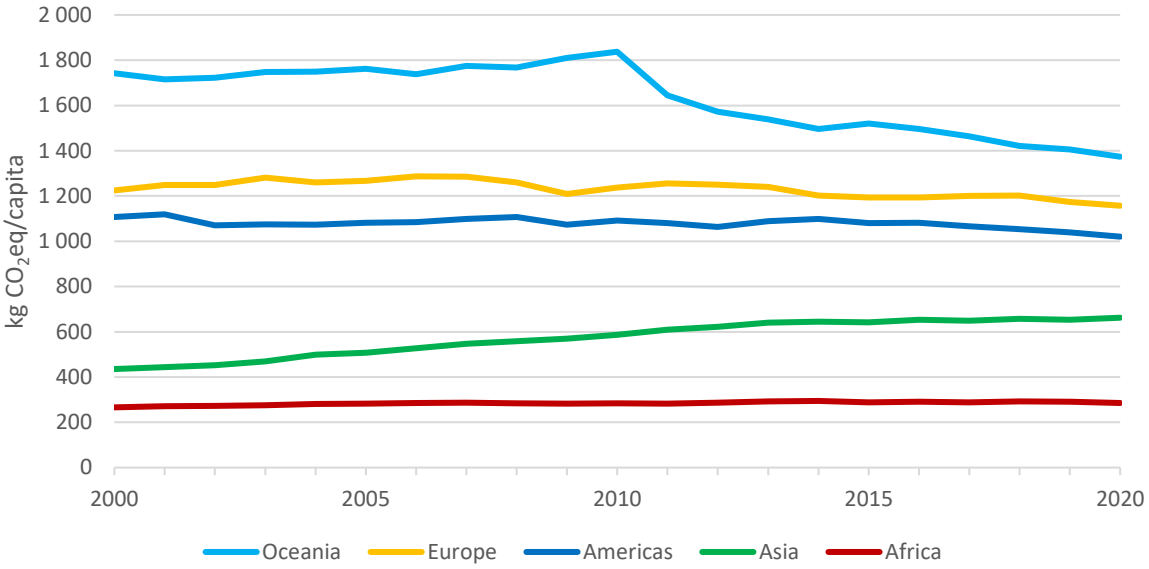
Figure 6: Pre- and post-production emissions by region



Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

In terms of pre- and post-production emissions per capita, regions exhibit important differences, with Oceania, Europe and the Americas having the highest emissions, but with a stable or even declining trend (-21 percent, -6 percent and -8 percent, respectively between 2000 and 2020). On the other hand, pre- and post-production emissions per capita are increasing moderately in Africa (+7 percent) and sharply in Asia (+52 percent over the same period). Africa's per capita emissions peaked in 2014 (294 kg CO_2eq/capita) and then slightly declined by 2020 (286 kg CO_2eq/capita). In contrast, Asia's per capita emissions increased from 435 kg CO_2eq/capita to 662 kg CO_2eq/capita. Factors influencing these trends likely include economic development, energy production methods, population growth, technology development and climate policies (Figure 7).

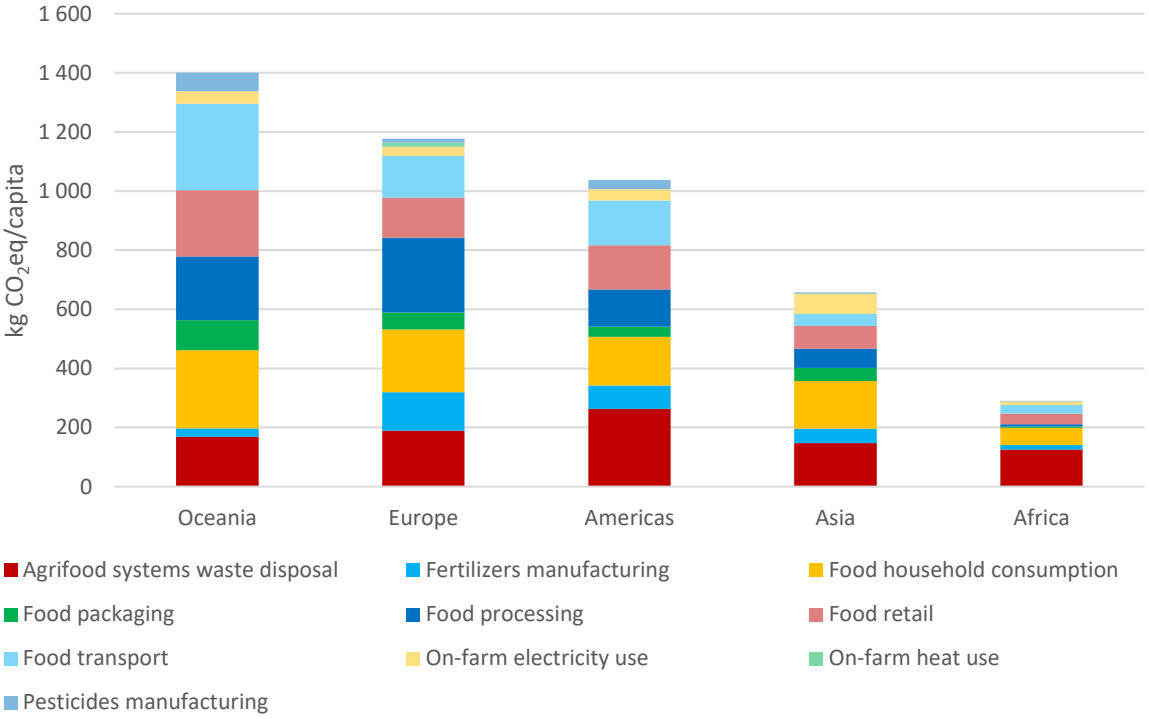
Figure 7: Pre- and post-production emissions per capita by region



Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

GHG per capita emissions from specific pre- and post-production activities vary substantially across regions (Figure 8). Europe has the highest per capita emissions in food processing (761 kg CO_2eq/capita), agrifood systems waste disposal (569 kg CO_2eq/capita), and food household consumption (637 kg CO_2eq/capita), indicating possible challenges in waste management and consumption patterns, and a robust food processing sector in the region. Oceania's highest per capita emissions are in food processing (647 kg CO_2eq/capita), food retail (671 kg CO_2eq/capita), and food transport (878 kg CO_2eq/capita), suggesting the region's dependence on transportation and the energy-intensive nature of food production and distribution. Asia's highest per capita emissions are in on-farm electricity use (204 kg CO_2eq/capita) and fertilizers manufacturing (147 kg CO_2eq/capita), reflecting the region's large agricultural sector and intensive use of fossil fuels. The Americas have their highest per capita emissions in agrifood systems waste disposal (790 kg CO_2eq/capita), which may be attributed to waste management practices and consumer behaviour. Africa has the lowest per capita emissions in most categories, though it faces significant emissions in food household consumption (175 kg CO_2eq/capita) and agrifood systems waste disposal (377 kg CO_2eq/capita).

Figure 8: Pre- and post-production emissions per capita by region and activity (2018–2020 average)

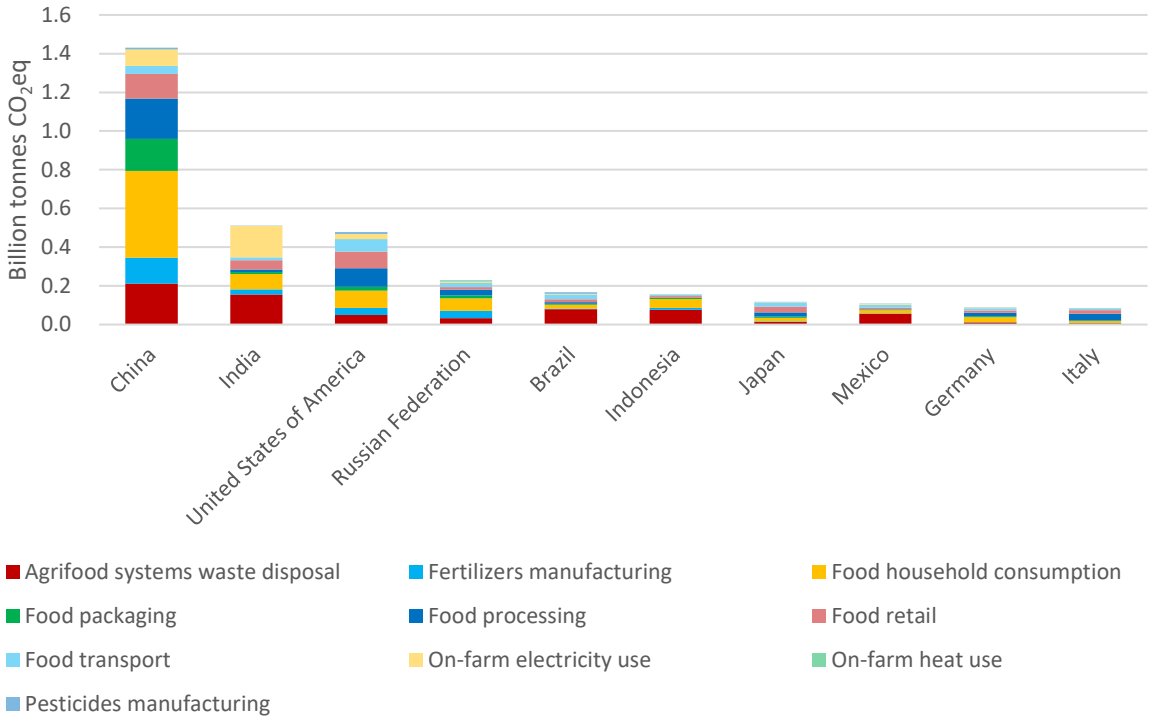


Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

COUNTRY

In 2020, the ten countries with the highest pre- and post-production emissions accounted for 2.9 Gt CO_2eq, or 53 percent of the global total. China dominated global pre- and post-production emissions, followed by India and the United States of America. However, important differences by components can be seen among countries (Figure 8). For example, China has the highest emissions in food household consumption (0.45 Gt CO_2eq on average between 2018 and 2020) and agrifood systems waste disposal (0.21 Gt CO_2eq), emphasizing the environmental impact of its large population and waste management challenges. India experiences substantial emissions from on-farm electricity use (0.16 Gt CO_2eq) and agrifood systems waste disposal (0.16 Gt CO_2eq), shedding light on the country's reliance on fossil fuels and inefficiencies in its agricultural sector. The United States of America also faces considerable emissions in food processing (0.10 Gt CO_2eq), food retail (0.09 Gt CO_2eq), and food transport (0.07 Gt CO_2eq), reflecting its extensive food production, distribution and consumption systems.

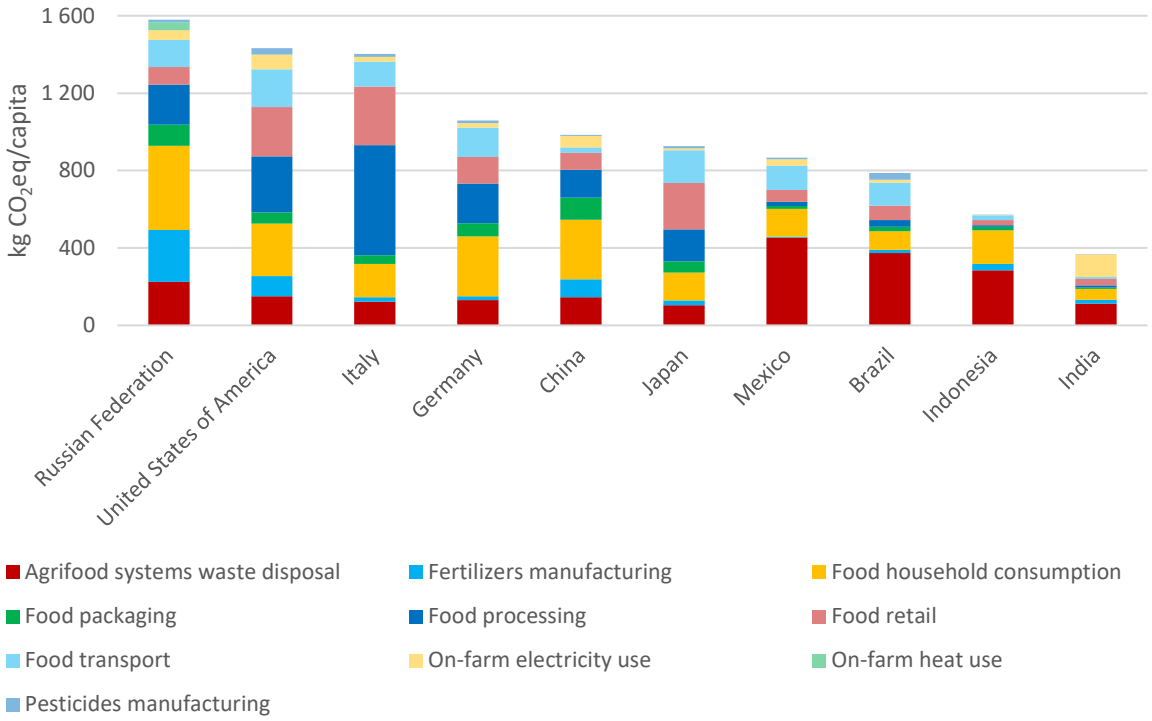
Figure 9: Pre- and post-production emissions, top countries (2018–2020 average)



Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

The analysis of per capita pre- and post-production emissions of the same top emitting countries depicts a different situation, with the Russian Federation, the United States of America and Italy having the highest emissions per capita, dominated by emissions of post-farm gate (post-production) activities (Figure 10). In China, food household consumption (308 kg CO_2eq/capita) and food processing (143 kg CO_2eq/capita) are the major contributors to emissions, while in India, agrifood systems waste disposal (112 kg CO_2eq/capita) and on-farm electricity use (117 kg CO_2eq/capita) are the most significant. In the United States of America, food household consumption (271 kg CO_2eq/capita) and food processing (289 kg CO_2eq/capita) have the highest per capita CO_2eq emissions. It is important to note that each country has distinct factors contributing to their emissions, making it essential to tailor mitigation strategies accordingly.

Figure 10: Pre- and post-production emissions per capita, top emitting countries (2018–2020 average)



Source: FAO. 2023. Emissions from pre- and post-agricultural production. In: *FAO*. Rome. Cited May 2023. https://www.fao.org/faostat/en/#data/GPP

EXPLANATORY NOTES

The FAOSTAT emissions database is composed of several data domains covering the GHG emissions from agrifood systems. The database includes non-CO_2 emissions from agricultural activities (i.e. methane [CH_4] and nitrous oxide [N_2O] emissions); CO_2 emissions from land use and land-use change, and from combustion of fossil fuels for pre- and post-production processes; as well as emissions of fluorinated gases used in the agrifood cold chain. The single domains are all summarized in the Emissions Totals domain, where the single-gas emissions are aggregated in CO_2eq, computed by applying the global warming potential from the Fifth Assessment Report of the IPCC (IPCC, 2014). A new pre- and post-production domain has been developed in 2023, covering all activities taking place before and after the farm gate.

FAO estimates of the emissions from pre- and post-production are available by country, regional and global aggregates over the period 1990–2020. The activity data underlying these emissions are based on country data on energy consumption officially reported to the United Nations Statistics Division (UNSD) and the International Energy Agency (IEA) (for occasional gap-filling where data were unavailable in the UNSD dataset). FAOSTAT domains (Fertilizers by Nutrient; Pesticides Use; and Pesticides Trade) are used to estimate emissions from fertilizers and pesticides manufacturing. Information on F-gas emissions originates from the Emissions Database for Global Atmospheric

Research (EDGAR) v7 (JRC, 2022). Emission information from the PRIMAP-hist dataset v2.4 (Gütschow *et al.*, 2022) is used to estimate emissions from countries not covered by UNSD Energy Statistics. The country-specific grid emission factors are provided by IEA and are updated to 2022. Methodologies for these estimates are described in dedicated working papers as follows: I) food transport; II) food systems waste disposal; III) fertilizers manufacturing, food processing, retail, packaging and household consumption.; IV) pesticides manufacturing; V) household food consumption; VI) Fluorinated gas emissions; and VII) energy used in agriculture.

The database also disseminates the underlying activity data of each category.

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ANNEX

ANNEX I COUNTRIES

Australia; Austria; Belarus; Belgium; Bulgaria; Canada; Croatia; Cyprus; Czechia; Denmark; Estonia; European Union; Finland; France; Germany; Greece; Hungary; Iceland; Ireland; Italy; Japan; Latvia; Liechtenstein; Lithuania; Luxembourg; Malta; Monaco; Netherlands (Kingdom of the); New Zealand; Norway; Poland; Portugal; Romania; Russian Federation; Slovakia; Slovenia; Spain; Sweden; Switzerland; Türkiye; Ukraine; United Kingdom of Great Britain and Northern Ireland; United States of America.

NON-ANNEX I COUNTRIES

Afghanistan; Albania; Algeria; Andorra; Angola; Antigua and Barbuda; Argentina; Armenia; Azerbaijan; Bahamas; Bahrain; Bangladesh; Barbados; Belize; Benin; Bhutan; Bolivia (Plurinational State of); Bosnia and Herzegovina; Botswana; Brazil; Brunei Darussalam; Burkina Faso; Burundi; Cabo Verde; Cambodia; Cameroon; Central African Republic; Chad; Chile; China; Colombia; Comoros; Congo; Cook Islands; Costa Rica; Côte d'Ivoire; Cuba; Democratic People's Republic of Korea; Democratic Republic of the Congo; Djibouti; Dominica; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Eritrea; Eswatini; Ethiopia; Fiji; Gabon; Gambia; Georgia; Ghana; Grenada; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; India; Indonesia; Iran (Islamic Republic of); Iraq; Israel; Jamaica; Jordan; Kazakhstan; Kenya; Kiribati; Kuwait; Kyrgyzstan; Lao People's Democratic Republic; Lebanon; Lesotho; Liberia; Libya; Madagascar; Malawi; Malaysia; Maldives; Mali; Marshall Islands; Mauritania; Mauritius; Mexico; Micronesia (Federated States of); Mongolia; Montenegro; Morocco; Mozambique; Myanmar; Namibia; Nauru; Nepal; Nicaragua; Niger; Nigeria; Niue; North Macedonia; Oman; Pakistan; Palau; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Qatar; Republic of Korea; Republic of Moldova; Rwanda; Saint Kitts and Nevis; Saint Lucia; Saint Vincent and the Grenadines; Samoa; San Marino; Sao Tome and Principe; Saudi Arabia; Senegal; Serbia; Seychelles; Sierra Leone; Singapore; Solomon Islands; Somalia; South Africa; South Sudan; Sri Lanka; State of Palestine; Sudan; Suriname; Syrian Arab Republic; Tajikistan; Thailand; Timor-Leste; Togo; Tonga; Trinidad and Tobago; Tunisia; Turkmenistan; Tuvalu; Uganda; United Arab Emirates; United Republic of Tanzania; Uruguay; Uzbekistan; Vanuatu; Venezuela (Bolivarian Republic of); Viet Nam; Yemen; Zambia; Zimbabwe.

This analytical brief was prepared by Alessandro Flammini, Kevin Karl, and Francesco N. Tubiello, with contributions by Griffiths Obli-Laryea, Giulia Conchedda and Xueyao Pan. Olivier Lavagne d'Ortigue provided editorial support.

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