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Greenhouse gas emissions from agrifood systems

Global, regional and country trends, 2000–2022

>> FAO Statistics Division

HIGHLIGHTS

- → **In 2022, global agrifood systems emissions were 16.2 billion tonnes of carbon dioxide equivalent (Gt CO_2eq), virtually unchanged from 2021, representing an increase of 10 percent since 2000. Estimated at 29.7 percent compared with 38 percent in 2000, their contribution to total emissions was below 30 percent for the first time on record.**
- → **Of the agrifood systems total, crop and livestock activities within the farm gate contributed 7.8 Gt CO_2eq globally, or 48 percent. They were virtually unchanged from 2021, with a 15 percent growth since 2000.**
- → **Emissions from land-use change were 3.1 Gt CO_2eq globally, or 19 percent of the total. They decreased by 1 percent since 2021 and by 30 percent since 2000.**
- → **Emissions from pre- and post-production, due to activities along the supply chain, were 5.3 Gt CO_2eq, or 33 percent of the total. They grew 52 percent since 2000.**
- → **Regional emissions changed little in 2022 compared to 2021, except for Oceania, where they grew 2.7 percent. Compared to 2000 however, they grew strongly in Africa (40 percent) and Asia (25 percent), while decreasing in Oceania (−29 percent), the Americas (−9 percent) and Europe (−6 percent).**
- → **In 2022, the agrifood systems emissions intensity was 2.6 kg CO_2eq per international dollar (I$) globally. It decreased continuously over time, by 0.4 percent compared to 2021 and by 39 percent since 2000.**
- → **The emissions intensity was above the world average in Africa (6.0 kg CO_2eq/I$), the Americas and Oceania (3.4 kg CO_2eq/I$), and lower in Asia and Europe (1.8–2.0 kg CO_2eq/I$). The decline was observed in all regions compared to 2000, ranging from −23.6 percent in Europe to −49.2 percent in Oceania.**

FAOSTAT AGRIFOOD SYSTEMS EMISSIONS

BACKGROUND

Agrifood systems account for about one-third of total anthropogenic greenhouse gas (GHG) emissions. They are generated within the *farm gate,* from crop and livestock production activities; by *land-use change*, caused by deforestation, biomass fires and peatland degradation processes often linked to land clearance for agriculture; and in *pre- and post-production processes*, comprising the supply chain including food manufacturing, retail, household consumption and food disposal (Tubiello *et al.*, 2022).

Statistics on the underlying activity data, emissions and indicators (shares of total economy, per capita emissions and emissions intensities) are disseminated in FAOSTAT at the country, regional and global levels, covering over 200 countries and territories, for the period 1961–2022 (FAO, 2024a), together with a comprehensive summary of emissions from the rest of the economy. Data are provided by single component gases – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (F-gases) – as well as in carbon dioxide equivalents (CO_2eq). This analysis focuses on the period 2000–2022. A special focus is given to the indicator on agrifood systems emissions per value of agricultural production, which contributes to Sustainable Development Goal (SDG) Indicator 2.4.1. proxy used to measure productive and sustainable agriculture (FAO, 2024b).

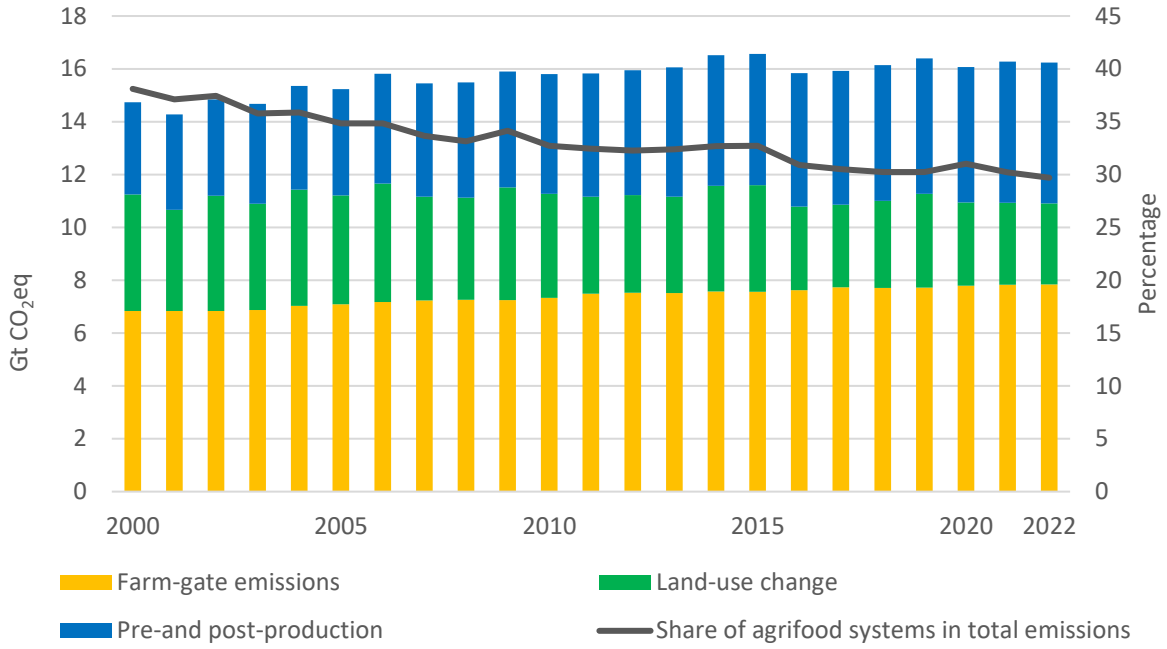
GLOBAL

In 2022, agrifood systems emissions were 16.2 billion tonnes of CO_2 equivalents (Gt CO_2eq), or 10 percent higher than in 2000, though with little change over the last decade (Figure 1). By comparison, global anthropogenic emissions reached 53.5 Gt CO_2eq in 2022, the highest level on record and a 42 percent increase since 2000. The share of agrifood systems emissions has continued to decrease over time, from 38 percent in 2000 to 29.7 percent in 2022, the first time on record below 30 percent (Figure 1).

Within agrifood systems, in 2022 the farm gate emitted 7.8 Gt CO_2eq, land-use change 3.1 Gt CO_2eq and pre- and post-production 5.3 Gt CO_2eq. While these levels were fairly similar to those recorded in 2021, compared to 2000 farm-gate emissions grew 15 percent; land use change emissions decreased 30 percent; while pre- and post-production emissions grew 52 percent. Farm-gate emissions continued to be the largest component of agrifood systems in 2022 (48 percent, up from 46 percent in 2000), whereas the contribution of land use change emissions diminished to 19 percent (compared to 30 percent in 2000). Emissions from pre- and post-production increased their contribution to total agrifood systems emissions to 33 percent, up from 24 percent in 2000.

Due to the trends in absolute emission values, emissions indicators showed a consistent decrease between 2000 and 2022. In 2022, per capita agrifood systems emissions were 2.0 t CO_2eq/cap, compared to 2.4 t CO_2eq/cap in 2000; emissions per area of agricultural land were 3.0 t CO_2eq/ha, compared to 3.8 t CO_2eq/ha in 2000. Finally, emissions per value of agricultural production decreased to 2.6 kg CO_2eq/I$ in 2022 compared to from 4.3 kg CO_2eq/I$ in 2000, a trend reflecting increased production efficiencies in relation to inputs and resource use.

Figure 1: Global agrifood systems emissions by component and share of agrifood systems emissions in total emissions

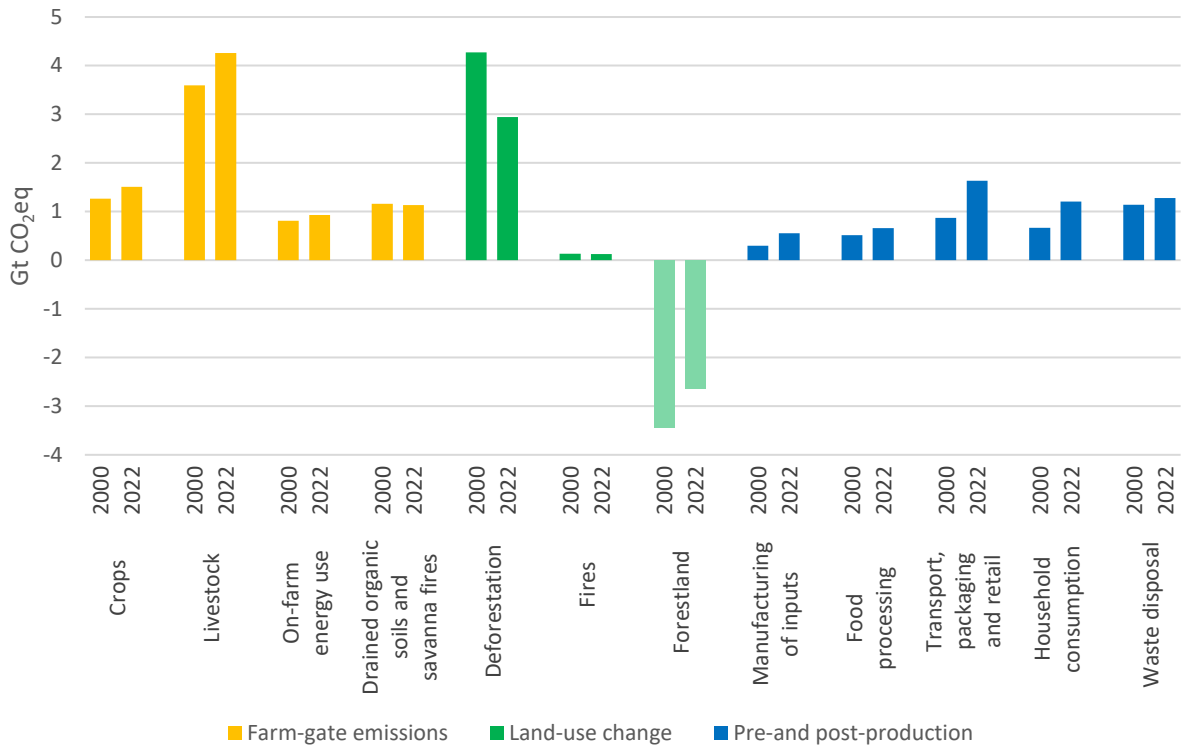


Source: FAO. 2024. FAOSTAT: Emissions totals. [Accessed November 2024]. https://www.fao.org/faostat/en/#data/GT. Licence: CC-BY-4.0. and FAO. 2024. FAOSTAT: Emissions indicators. [Accessed November 2024]. https://www.fao.org/faostat/en/#data/EM. Licence: CC-BY-4.0.

In 2022, the largest component of agrifood systems emissions globally was livestock, totalling 4.3 Gt CO_2eq from methane generated in enteric fermentation and nitrous oxide from manure. The second most important component was deforestation, at 3.0 Gt CO_2eq from biomass carbon losses, while the third was packaging, transport and retail, generating 1.6 CO_2eq from fossil fuel energy use (Figure 2).

Compared to 2000, livestock emissions grew by 19 percent, while deforestation emissions decreased by 31 percent (Figure 2). This suggests a decoupling over time between the two processes, reflecting known decadal trends towards more intensive livestock systems, needing less land clearance for grazing. At the same time, the strongest growth was recorded in supply chain and consumption processes. Emissions from the manufacturing of inputs, transport, packaging and retail, and household consumption all grew more than 80 percent from 2000 to 2022.

Figure 2: Agrifood systems emissions by component



Note: Emissions/removals on forestland are not accounted for within agrifood systems in this analysis and are shown here for comparison. They are disseminated in FAOSTAT as part of land use, land use change and forestry (LULUCF) emissions.

Source: FAO. 2024. FAOSTAT: Emissions totals. [Accessed November 2024]. https://www.fao.org/faostat/en/#data/GT. Licence: CC-BY-4.0.

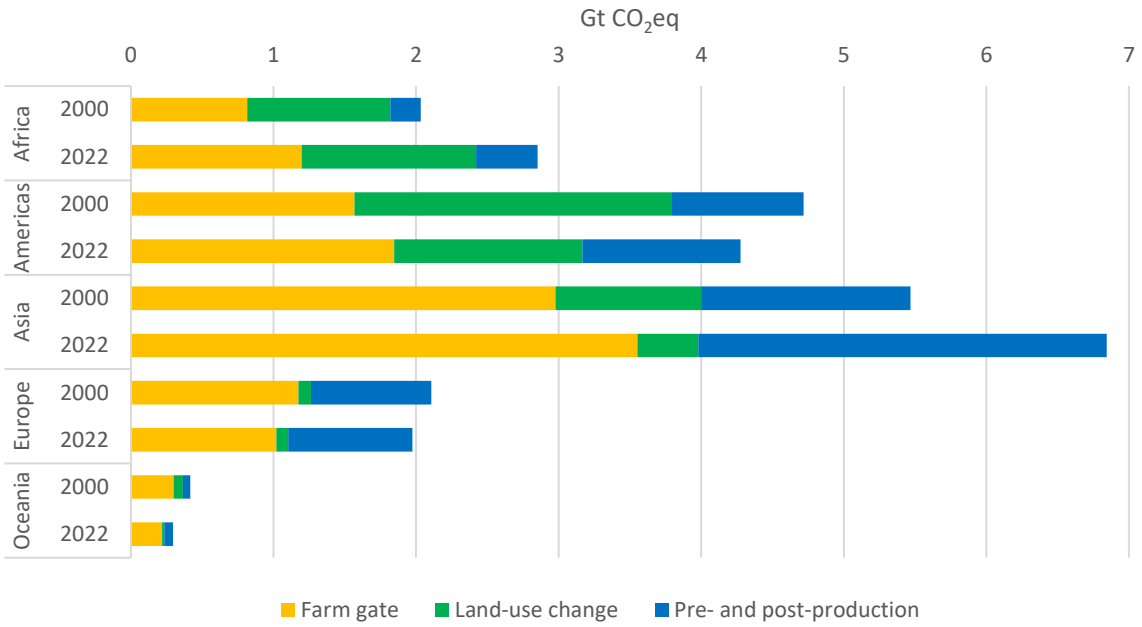
REGIONAL

Asia (6.8 Gt CO_2eq) was the largest contributor to regional agrifood systems emissions in 2022, followed by the Americas (4.3 Gt CO_2eq), Africa (2.9 Gt CO_2eq), Europe (2.0 Gt CO_2eq) and Oceania (0.3 Gt CO_2eq) (Figure 3). Emissions produced within the farm gate remained the dominant component of agrifood systems emissions in all regions except Africa, specifically in Oceania (71 percent), Europe and Asia (52 percent) and the Americas (43 percent). In Africa, farm-gate emissions accounted for 42 percent of the total, slightly less than those from land-use change (43 percent).

Emissions in Africa and the Americas had significant land-use change components of agrifood systems emissions (1.2–1.3 Gt CO_2eq), respectively 43 percent and 31 percent of the total. Conversely, significant pre- and post- production emissions were observed in Asia (42 percent) and Europe (43 percent).

Compared to 2000, in 2022 agrifood systems emissions increased greatly in Africa (40 percent) and Asia (25 percent), whereas they decreased in Oceania (25 percent), the Americas (9 percent) and Europe (6 percent).

Figure 3: Agrifood systems emissions by component and region



Source: FAO. 2024. FAOSTAT: Emissions totals. [Accessed November 2024]. https://www.fao.org/faostat/en/#data/GT. Licence: CC-BY-4.0.

Oceania was the largest per capita emitter (6.5 t CO_2eq/cap) in 2022, followed by the Americas (4.1 t CO_2eq/cap), respectively three and two times the world average per capita emissions. Next were Europe (2.7 t CO_2eq/cap), Africa (2.0 t CO_2eq/cap) and Asia (1.5 t CO_2eq/cap) (Table 1). Emissions per hectare of agricultural land ranged 0.6–2.2 t CO_2eq/ha, with Oceania the lowest per area emitter, and Europe and Asia the highest. Finally, emissions per value of agricultural production ranged 1.8–6.0 kg CO_2eq/I$, with Africa having the highest intensity value (6.0 kg CO_2eq/I$), and Asia and Europe the lowest (1.8–2.0 kg CO_2eq/I$).

Emissions per value of agricultural production decreased consistently by 25–50 percent since 2000 across regions. Per capita emissions also decreased from 2000 to 2022, but with much more variability. Farm-gate emissions per agricultural land area decreased in Europe and Oceania (by 8–9 percent), whereas they increased in Asia and the Americas by about 20 percent and by 36 percent in Africa (Table 1).

Table 1: Emissions indicators by region

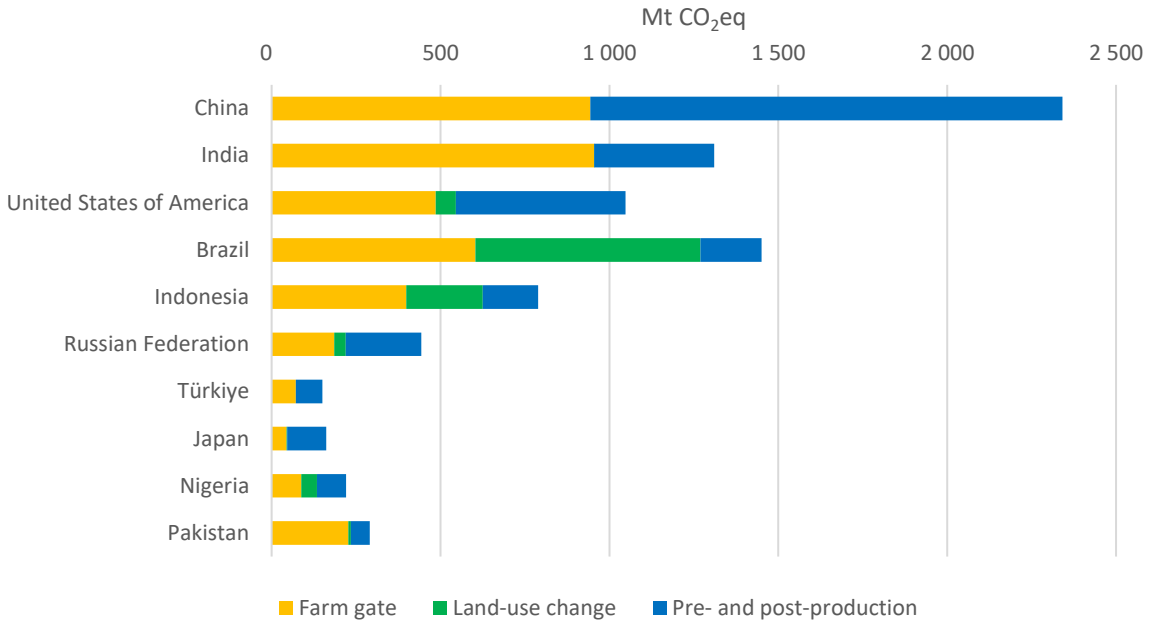
	Per value of agricultural production			Per capita			Per area of agricultural land		
	2000	2022	Change	2000	2022	Change	2000	2022	Change
	kg/I$	kg/I$	%	t/cap	t/cap	%	t/ha	t/ha	%
Africa	9.0	6.0	−33	2.5	2.0	−19	0.75	1.02	36
Americas	5.9	3.3	−44	5.7	4.1	−27	1.36	1.66	22
Asia	3.2	1.9	−43	1.5	1.5	−1	1.77	2.14	21
Europe	2.6	2.0	−24	2.9	2.7	−9	2.42	2.22	−8
Oceania	6.7	3.5	−48	13.3	6.5	−51	0.64	0.58	−9
World	4.3	2.6	−39	2.4	2.0	−15	1.40	1.64	17

Source: FAO. 2024. FAOSTAT: Emissions indicators. [Accessed November 2024.] https://www.fao.org/faostat/en/#data/EM. Licence: CC-BY-4.0.

COUNTRY

Figure 4 presents agrifood systems emissions by component for the countries with the largest value of agricultural production in 2022: China (USD 1 398 billion; 2 342 Mt CO_2eq), India (USD 480 billion; 1 310 Mt CO_2eq), the United States of America (USD 361 billion; 1 048 Mt CO_2eq), Brazil (USD 197 billion; 1 450 Mt CO_2eq), Indonesia (USD 146 billion; 789 Mt CO_2eq), the Russian Federation (USD 100 billion; 443 Mt CO_2eq), Türkiye (USD 96 billion; 150 Mt CO_2eq), Japan (USD 91 billion; 161 Mt CO_2eq), Nigeria (USD 73 billion; 221 Mt CO_2eq) and Pakistan (USD 69 billion; 291 Mt CO_2eq). These countries included seven of the top ten GHG emitters, and together accounted for half of the 2022 world-total agrifood systems emissions. Among these top ten, the farm gate was the predominant component of agrifood systems emissions, except for Brazil and China. In the former, emissions from land-use change were the largest contributor (46 percent of the total), while in the latter, emissions from pre- and post-production activities along the supply chain were the largest component (60 percent). In fact, supply chain emissions accounted for 60 percent or more of the total agrifood systems emissions in 61 countries and territories in 2022. These included major agricultural producers such as Japan (with a share of 71 percent of agrifood systems emissions generated by the supply chain), Italy (68 percent), the Republic of Korea (67 percent). They also included many food-importing countries such as Lebanon, Oman, Qatar, Saudi Arabia and the United Arab Emirates, each having shares of supply-chain emissions of about 80 percent of the agrifood systems total. The pre- and post-production sector contributed almost entirely to national agrifood systems emissions (above 90 percent) in countries such as Singapore, Trinidad and Tobago, Bahrain and Mauritius.

Figure 4: Agrifood systems emissions, top ten countries by value of agricultural production (2022)



Note: Countries are listed in descending order of their value of agricultural production expressed in constant 2014–2016 USD, from China (first) to Pakistan (tenth).

Source: FAO. 2024. FAOSTAT: Emissions Totals. [Accessed November 2024]. https://www.fao.org/faostat/en/#data/GT. Licence: CC-BY-4.0.

Normalizing total emissions by population, agricultural area, and value of agricultural production makes countries more comparable. Results for 2022 show that agrifood systems emissions indicators varied across countries within much narrower ranges than the corresponding absolute emissions levels. In general, 75 percent of country values (the upper interquartile range) were lower than about twice the median value for each indicator.

Table 2: Emissions indicators, summary statistics (2022)

Emissions indicator	Median	Interquartile range	Minimum	Maximum
Per capita (t CO_2eq/cap)	1.8	1.2–2.9	0.1	5.2
Per value of agricultural production (kg CO_2eq/I$)	2.6	1.6–6.2	0.5	12.4
Per area of agricultural land (t CO_2eq/ha)	3.0	1.5–6.5	0.1	13.6

Note: Minimum and maximum values are computed as 1.5 times the interquartile range limits, representing in a box plot the lowest and highest data point excluding outliers.

Source: Based on FAO. 2024. FAOSTAT: Emissions indicators. [Accessed November 2024]. https://www.fao.org/faostat/en/#data/EM. Licence: CC-BY-4.0.

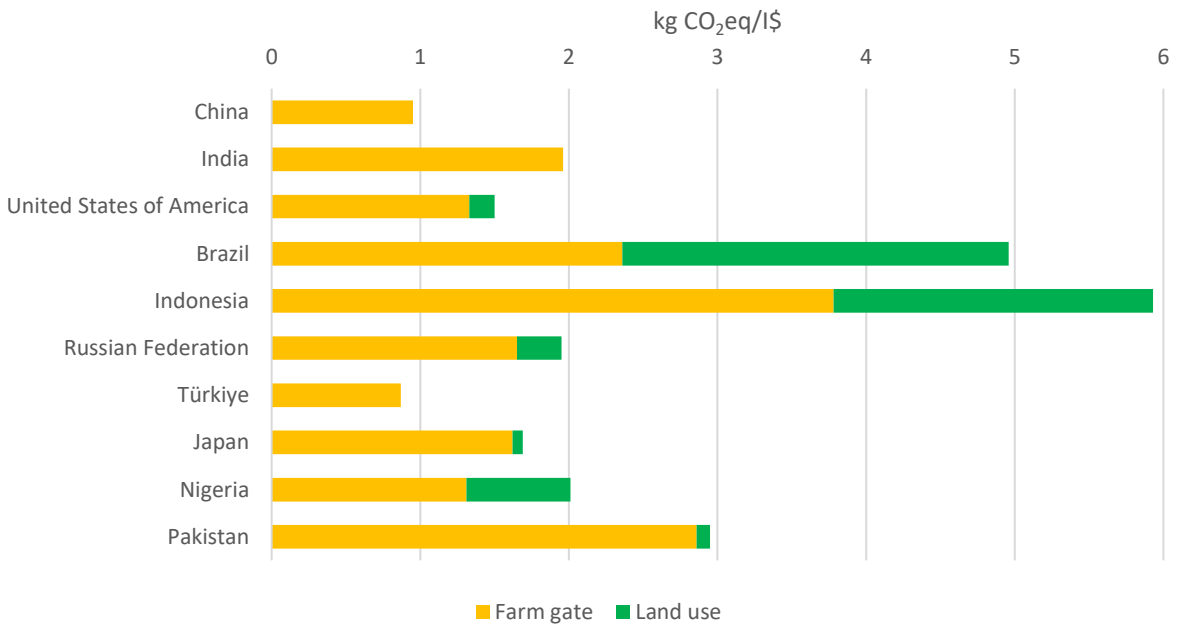
EMISSIONS INTENSITY OF AGRICULTURAL PRODUCTION

In 2022, among the top agricultural producers mentioned in Figure 4, Indonesia (5.9 kg CO_2eq/I$) and Brazil (5.0 kg CO_2eq/I$) had the highest emissions intensities (Figure 5), nearly double the global median (x2.6kg CO_2eq/I$). Conversely, China, Türkiye (about 1.0 kg CO_2eq/I$ each) were among the world's best performers for this indicator, followed by the United States of America (1.5 kg CO_2eq/I$). The emissions intensities of Japan, India, Nigeria, the Russian Federation (1.7–2.0 kg CO_2eq/I$) were below though close to the world median, with Pakistan above (3.0 kg CO_2eq/I$).

The contribution of farm-gate and land-use change processes to the emissions intensity varied across countries: in particular, land-use change processes contributed to high values in Brazil and Indonesia, reflecting the negative impacts of deforestation and peatland degradation in those countries.

In absolute terms, the countries with the highest intensities (just below 12 kg CO_2eq/I$) included the Bolivarian Republic of Venezuela, Iceland, the Gambia, Mauritania, Paraguay and Angola. Conversely, the lowest intensity values (below 1 kg CO_2eq/I$) were those for Costa Rica, Ghana, Greece, Egypt, Lebanon, the Republic of Moldova and Spain, in addition to China and Türkiye discussed above. In addition, Israel, Italy, Portugal, North Macedonia, Sri Lanka and the Syrian Arab Republic had values below the interquartile range.

Figure 5: Emissions on agricultural land per value of agricultural production, top ten countries by value of agricultural production, 2022



Note: Land use in the figure is calculated as the difference between emissions on agricultural land and farm-gate emissions.

Source: FAO. 2024. FAOSTAT: Emissions indicators. [Accessed November 2024]. https://www.fao.org/faostat/en/#data/EM

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 F-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 applying the global warming potential from the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2014). In the domain, the single categories of emissions are further summarized by the Food and Agriculture Organization of the United Nations (FAO) aggregates of farm-gate, land-use change and pre- and post-production to break down the emissions from agrifood systems, as well as by the categories of the IPCC Agriculture, Forestry and Other Land Use (AFOLU) sector of the national GHG inventories (NGHGI) to the United Nations Framework Convention on Climate Change (UNFCCC).

FAO estimates of the emissions from agrifood systems are available by country, regional and global aggregates over the period 1961–2022 for agriculture production processes, i.e. crop and livestock activities. The activity data underlying these emissions are based on country data officially reported to FAO (for instance, livestock numbers, harvested area, fertilizers use in agriculture). Projections to 2030 and 2050 are also available. They are computed with respect to the 2005–2007 baseline, following Alexandratos and Bruinsma (2012).

Land use and land-use change emissions and removals are instead generally available only for the period 1990–2020. The activity data for forests are collected from FAO Forest Resources Assessments (FRA) in five-year cycles. Geospatial data complement existing national statistics and provide the source of activity data for emissions on drained organic soils (1990–2022), savanna, forest fires and fires in organic soils (1990–2023).

Data on Energy Use, for all components of pre- and post-production as well as the emissions from other economic sectors are available for the period 1990–2022. Emissions from pre- and post-production processes, including those from Food Systems Waste Disposal are calculated by FAO based on activity data (mostly energy use) from the United Nations Statistics Division (UNSD), the International Energy Agency (IEA) and other third parties. For transparency and completeness, Emissions Totals integrates information on the emissions from other economic sectors from the PRIMAP-hist dataset v2.4 (Gütschow *et al.*, 2024).

The database disseminates in separate domains the shares of emissions of each category over total emissions. Associated per capita values are also reported in Emissions shares.

For emissions from fires in organic soils, in line with existing literature, only the emissions from South-eastern Asian countries (e.g. Brunei Darussalam, Indonesia and Malaysia) were considered anthropogenic. Conversely, emissions estimates for the other countries and territories provided in FAOSTAT were not considered anthropogenic, to reflect the lack of evidence to this end in existing literature. As a result, although the emissions from fires in organic soils are disseminated for all the countries and territories where these fires occur, the values from countries in the FAOSTAT regional aggregate “South-eastern Asia” only contribute to relevant thematic, regional and world total aggregates.

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