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FAOSTAT ANALYTICAL BRIEF 50

Greenhouse gas emissions from agrifood systems

Global, regional and country trends, 2000–2020

>> FAO Statistics Division

HIGHLIGHTS

- → **In 2020, global agrifood systems emissions were 16 billion tonnes of carbon dioxide equivalent (Gt CO_2eq), an increase of 9 percent since 2000.**
- → **Per capita emissions decreased by 15 percent over the same period, to 2.0 t CO_2eq per capita in 2020.**
- → **The share of agrifood systems emissions in emissions from all sectors dropped from 38 percent in 2000 to 31 percent in 2020, due to much faster growth in non-food emissions.**
- → **Globally, the farm gate in 2020 represented nearly half of total agrifood systems emissions, pre- and post-production processes contributed one-third and land-use change one-fifth.**
- → **In 2020, at the regional level, farm-gate emissions were the largest component in Oceania (71 percent), Asia (50 percent) and the Americas (43 percent). Land-use change was the largest contributor in Africa (44 percent), while pre- and post-production processes were the largest contributor in Europe (53 percent).**
- → **Per capita emissions were the highest in Oceania (6.5 t CO_2eq per capita) and the lowest in Asia (1.4 t CO_2eq per capita). Agrifood systems accounted for the largest share in emissions from all sectors in Africa (59 percent) and the lowest in Asia (near 25 percent).**
- → **Globally, emissions intensities in 2020 varied between 1 kg CO_2eq/kg and 30 kg CO_2eq/kg for meat (with the lowest values for chicken meat and the highest for beef). The global farm-gate emissions intensity for cow milk was 1 kg CO_2eq/kg, about 24 percent less than in 2000.**

FAOSTAT EMISSIONS

BACKGROUND

Agrifood systems account for one-third of total anthropogenic greenhouse gas (GHG) emissions (Crippa *et al.*, 2021; Tubiello *et al.*, 2021). They are generated within the *farm gate,* by crop and livestock production activities; by *land-use change*, for instance deforestation and peatland drainage to make room for agriculture; and in *pre- and post-production processes*, such as food manufacturing, retail, household consumption and food disposal (Tubiello *et al.*, 2022).

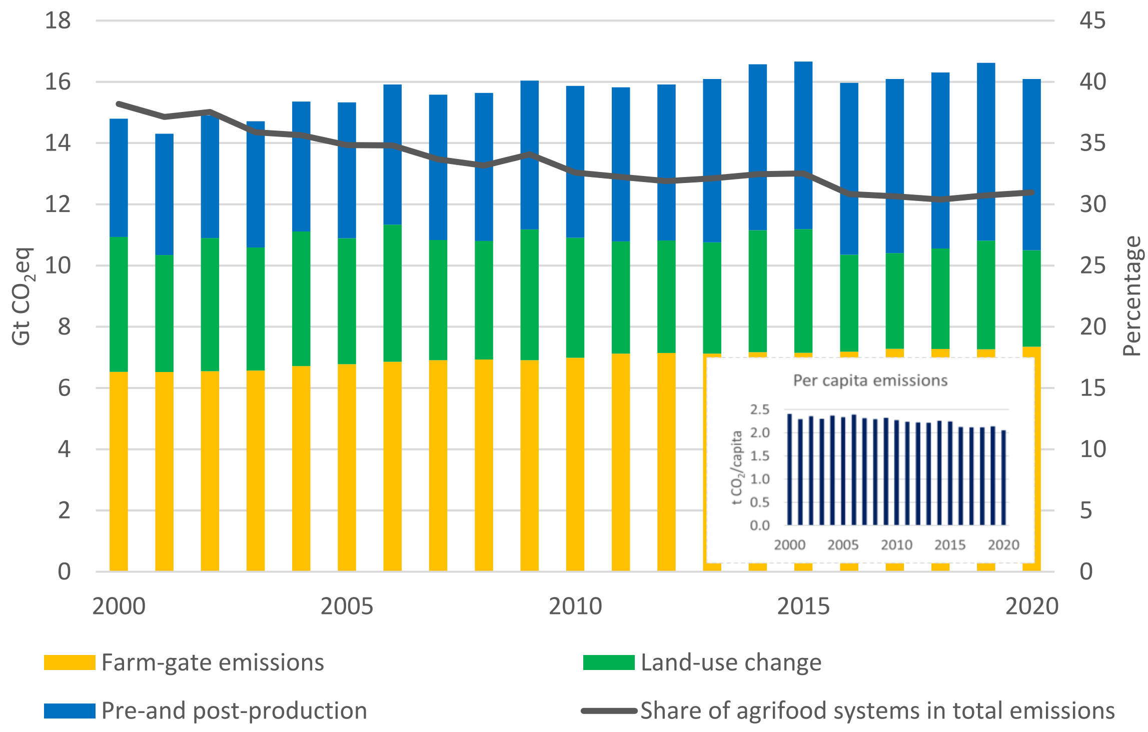
Statistics on underlying activity data, emissions and indicators (emissions per capita, shares in total emissions, and emissions per commodity) are disseminated in FAOSTAT at country, regional and global levels, covering over 200 countries and territories, for the period 1961–2020 (FAO, 2022a, 2022b, 2022c), 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.

GLOBAL

In 2020, global annual anthropogenic GHG emissions reached 52 Gt CO_2eq, down 4 percent from 54 Gt CO_2eq in 2019 – reflecting a well-documented reduction in economic activities due to the COVID-19 pandemic. They were nonetheless 34 percent higher than in 2000. At the same time, emissions from agrifood systems were 16 Gt CO_2eq in 2020, down 3 percent from 2019, but 9 percent higher than in 2000. The share of agrifood systems in total emissions in 2020 (31 percent) confirmed the steady downward trend from the levels of 2000 (38 percent), a consequence of agrifood systems emissions growing significantly more slowly than the rest of the economy, dominated by fossil fuels combustion for energy use. In fact, non-food emissions grew nearly 50 percent since 2000. Agrifood systems emissions per capita likewise decreased over the period, from 2.4 t CO_2eq/cap to 2.0 t CO_2eq/cap (Figure 1).

Among the three components of agrifood systems in 2020, farm-gate emissions were nearly half of the total (7.4 Gt CO_2eq), followed by emissions from pre- and post-production (5.6 Gt CO_2eq) and land-use change (3.1 Gt CO_2eq). Over the period 2000-2020, pre- and post-production emissions grew the fastest (45 percent); emissions within the farm gate increased by 13 percent while those from land-use change significantly decreased (-29 percent), largely a result of the long-term slowdown in deforestation rates (Figure 1). With respect to 2019, land-use change emissions in 2020 decreased significantly (-11 percent) due to lower fire intensity in degraded tropical peatlands. Pre- and post-production emissions also decreased (-4 percent), in line with the COVID-19 decrease in fossil fuel energy use. Conversely, emissions from the farm gate increased 1 percent in 2020, consistently with recent FAOSTAT statistics of crop and livestock production, which had indicated the limited impact of the COVID-19 pandemic at the global level on this primary sector.

Figure 1: Global agrifood systems emissions by component and indicator

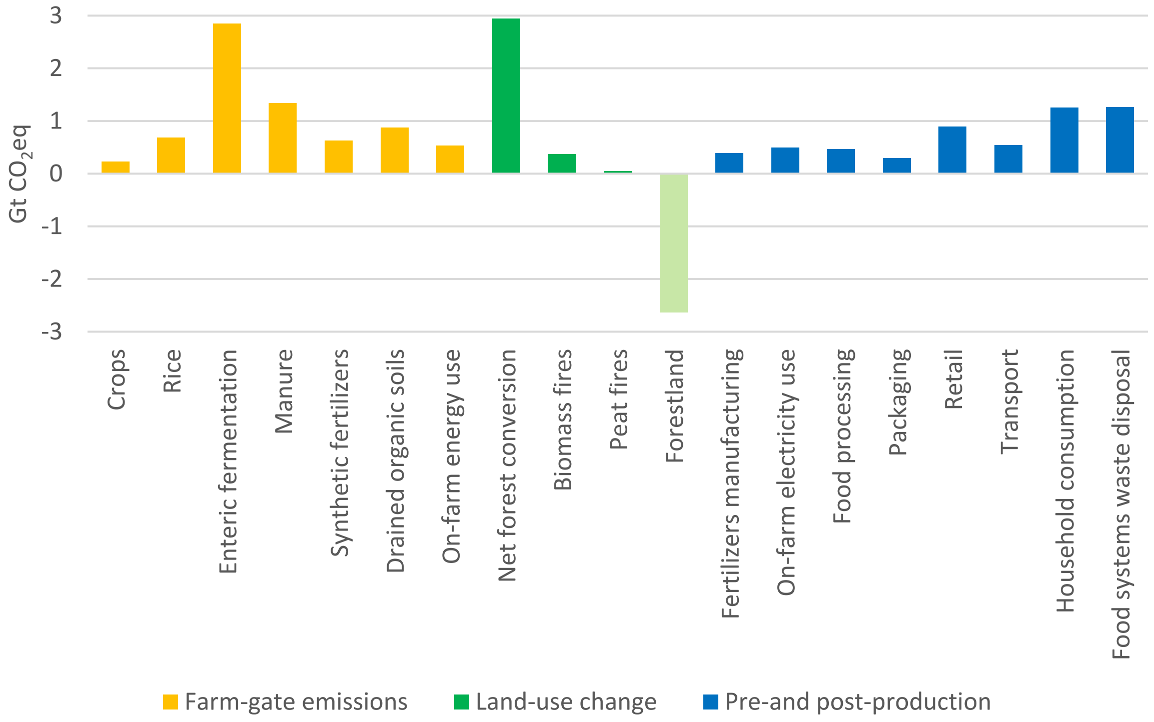


Source: FAO. 2022. Emissions totals. In: *FAO*. Rome. Cited October 2022. https://www.fao.org/faostat/en/#data/GT and FAO. 2022. Emissions shares. In: *FAO*. Rome. Cited October 2022. https://www.fao.org/faostat/en/#data/EM

When breaking down agrifood systems emissions by gas, CO_2 emissions remained stable to 7.9 Gt as the reduced emissions from deforestation were cancelled out by increased CO_2 emissions in pre- and post-production processes; CH_4 emissions grew from 173 Mt to 193 Mt (+14 percent) and N_2O emissions increased from 7 Mt to 9 Mt (+12 percent). Over the past two decades, emissions from agrifood systems decreased from 29 percent to 21 percent of the total for CO_2, from 58 percent to 53 percent for CH_4, while the share of N_2O agrifood systems emissions remained at 78 percent over the entire period. Finally, the share of F-gases generated by cold chains, largely in food retail, decreased from 32 percent to 26 percent.

A further breakdown by subcomponent helps to highlight the relative importance of specific processes across global production, supply and consumption chains. In 2020, the most important contributors to global agrifood systems emissions were CO_2 emissions from deforestation (2.9 Gt CO_2eq) and CH_4 from enteric fermentation of ruminant livestock (2.8 Gt CO_2eq), representing together nearly 40 percent of the total. Other important global contributors were CH_4 emissions from livestock manure and food systems waste disposal, and CO_2 emissions from household consumption, at about 1.3 Gt CO_2eq each. All these components are shown in Figure 2.

Figure 2: Detailed composition of agrifood systems emissions (2020)

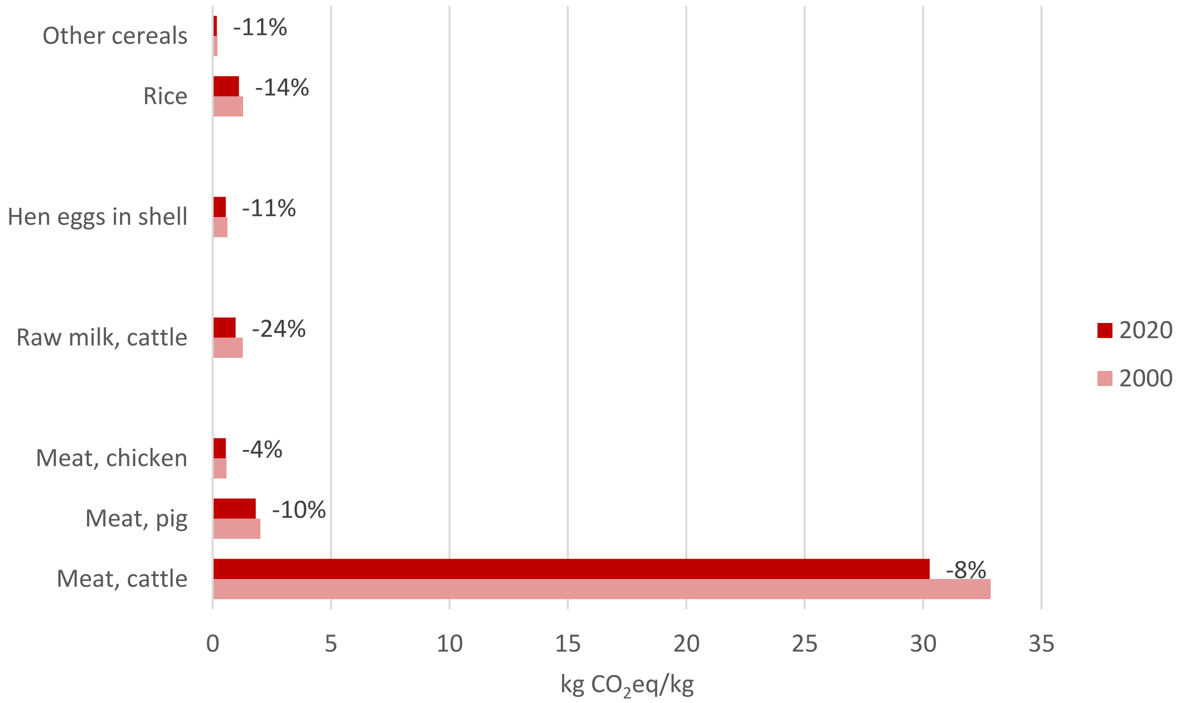


Note: Emissions/removals on forestland (which are not part of agrifood systems emissions) are also shown as included in the FAOSTAT Emissions database.

Source: FAO. 2022. Emissions totals. In: *FAO*. Rome. Cited October 2022. https://www.fao.org/faostat/en/#data/GT

Emissions intensities, defined as the GHG emissions within the farm gate per unit weight of product (kg CO_2eq/kg product) were computed for several primary commodities: six types of meat (buffalo, cattle [beef], chicken, goat, pig and sheep), four types of milk (camel, cow, goat and sheep), hen eggs, rice, and other cereals (combining the intensities of barley, maize, millet, oats, rye, sorghum and wheat). Figure 3 focuses on a subset of them. In 2020, farm-gate emissions by kg of beef were 32 kg CO_2eq/kg, a high value that is largely due to methane production by ruminant fermentation. Indeed, the emissions intensities of monogastric animals were much smaller: nearly 2 kg CO_2eq/kg for pork and less than 1 kg CO_2eq/kg for chicken. The global emissions intensity of cow milk was 1 kg CO_2eq per kg of milk. The global emissions intensities of cereals were 1 kg CO_2eq/kg for rice and 0.2 kg CO_2eq/kg for other cereals. The GHG intensity of hen eggs was 0.6 kg CO_2eq/kg. Farm-gate emissions intensities had a marked long-term declining trend since 2000 across all commodities, with the largest reduction computed for cow milk (-24 percent) and rice (-14 percent) (Figure 3). Such reductions reflect increases in crop and livestock production efficiency over time, often achieved through economies of scale.

Figure 3: Global emissions intensities (2020) and percentage change since 2000



Source: FAO. 2022. Emissions intensities. In: *FAO*. Rome. Cited October 2022 https://www.fao.org/faostat/en/#data/EI

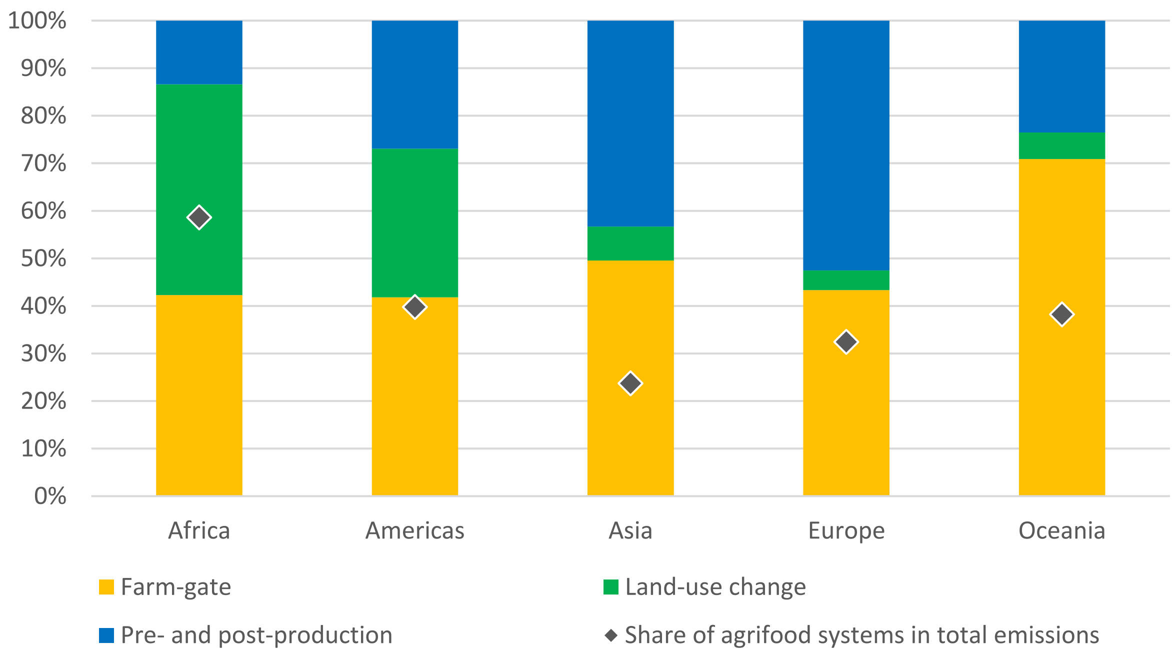
REGIONAL

In 2020, total agrifood systems emissions were the largest in Asia (6.6 Gt CO_2eq) and the Americas (4.3 Gt CO_2eq), mainly a reflection of area and population. The relative role of the three components in total emissions from agrifood systems varied across regions, reflecting structural differences in production and distribution systems around the world (Figure 4). Emissions in Africa and the Americas had significant land-use change components (1.2–1.3 Gt CO_2eq), respectively 44 percent and 31 percent of the total agrifood systems emissions, reflecting the extensive nature of agriculture in both regions and its impact on surrounding ecosystems, mainly via deforestation. Conversely, significant pre- and post- production emissions were observed in Asia (43 percent, or 2.9 Gt CO_2eq) and especially in Europe (53 percent or 1.0 Gt CO_2eq), where this component was in fact the largest contributor. Emissions produced within the farm gate remained the dominant component of agrifood systems emissions in Oceania (71 percent), Asia (50 percent) and the Americas (42 percent). Furthermore, emissions from agrifood systems had significantly different trends across regions between 2000 and 2020. They decreased by 33 percent in Oceania, 9 percent in the Americas and 1 percent in Europe, while they grew by 35 percent in Africa and 20 percent in Asia.

Oceania was the largest per capita emitter (6.5 t CO_2eq/cap) in 2020, followed by the Americas (4.2 t CO_2eq/cap), respectively three and two times larger than the world average. Europe (2.7 t CO_2eq/cap) and Africa (2.1 t CO_2eq/cap) had values closer to the world average, while Asia was the lowest per capita emitter at 1.4 t CO_2eq/cap.

Africa had the largest share of agrifood systems in total emissions (59 percent) in 2020, consistently with the predominance of agriculture in most economies of the region. The shares were much lower in the Americas (40 percent), Oceania (38 percent) and Europe (32 percent) and lowest in Asia (23 percent), reflecting the economic efficiency of more intensive mixed and modern production systems (Figure 4).

Figure 4: Regional agrifood systems emissions and share in total emissions (2020)



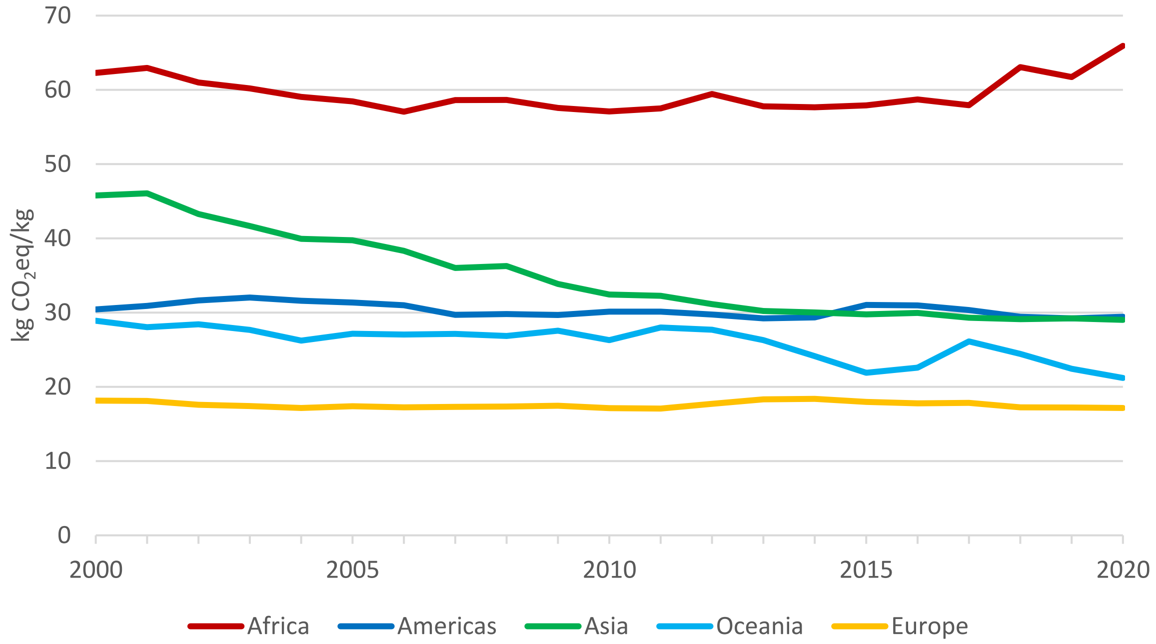
Source: FAO. 2022. Emissions totals. In: *FAO*. Rome. Cited October 2022. https://www.fao.org/faostat/en/#data/GT and FAO. 2022. Emissions shares. In: *FAO*. Rome. Cited October 2022. https://www.fao.org/faostat/en/#data/EM

The intensities of farm-gate emissions varied significantly among regions and followed different trends over the period depending on the commodity, as shown using the examples of beef and cow milk. These regional features generally reflected known differences across regions in farm production systems, from traditional to mixed systems to modern agriculture.

The 2020 emissions intensity of beef was highest in Africa (66 kg CO_2eq/kg), followed by the Americas and Asia (29 kg CO_2eq/kg in both regions), Oceania (21 kg CO_2eq/kg) and Europe (17 kg CO_2eq/kg) (Figure 5). Between 2000 and 2020, most regions exhibited a downward trend in the emissions intensity of beef. The largest reductions were found in Asia and Oceania (-37 percent and -27 percent, respectively) whereas Europe and the Americas showed smaller reductions in the 3–5 percent range. Africa was the only region with an increase (6 percent).

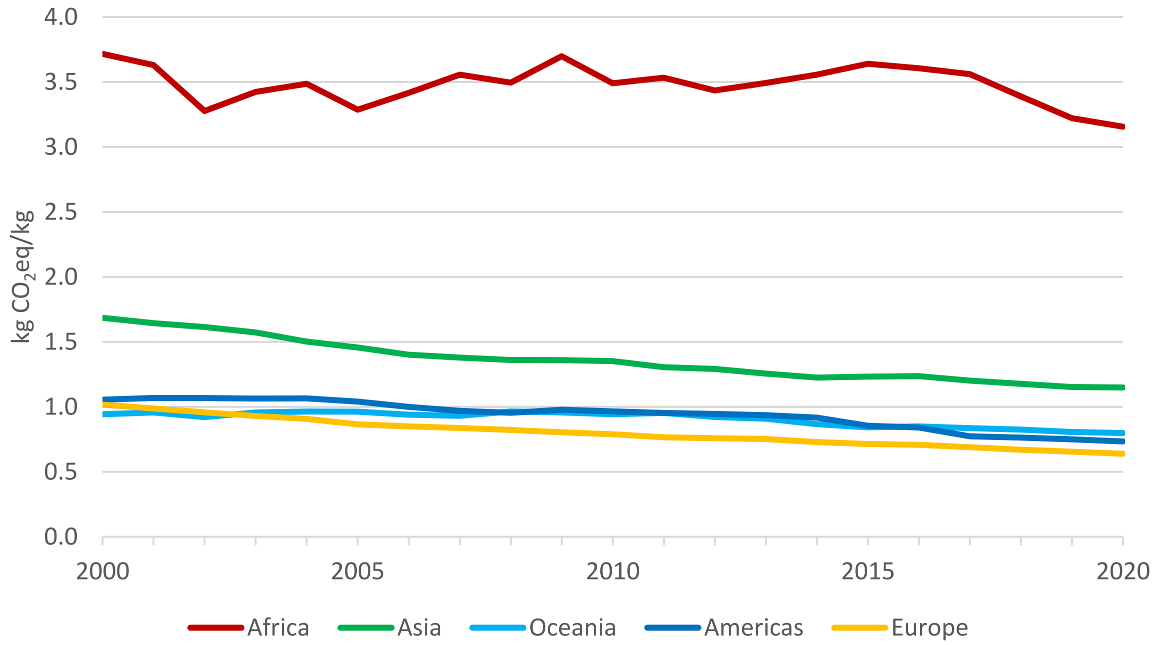
In 2020, the emissions intensity for milk was the highest in Africa (3.1 kg CO_2eq/kg) and about three times more than in the other regions. The intensity reached 1.1 kg CO_2eq/kg in Asia, 0.9 kg CO_2eq/kg in Oceania, and had comparable values (about 0.7 kg CO_2eq per kg of product) in the Americas and Europe. All the regions greatly reduced the emissions intensity of cow milk over 2000–2020: by about 40 percent in Europe, compared to around 30 percent in Asia and the Americas, and 15 percent for both Africa and Oceania (Figure 6).

Figure 5: Emissions intensity of beef by region



Source: FAO. 2022. Emissions intensities. In: *FAO*. Rome. Cited October 2022. https://www.fao.org/faostat/en/#data/EI

Figure 6: Emissions intensity of cow milk by region

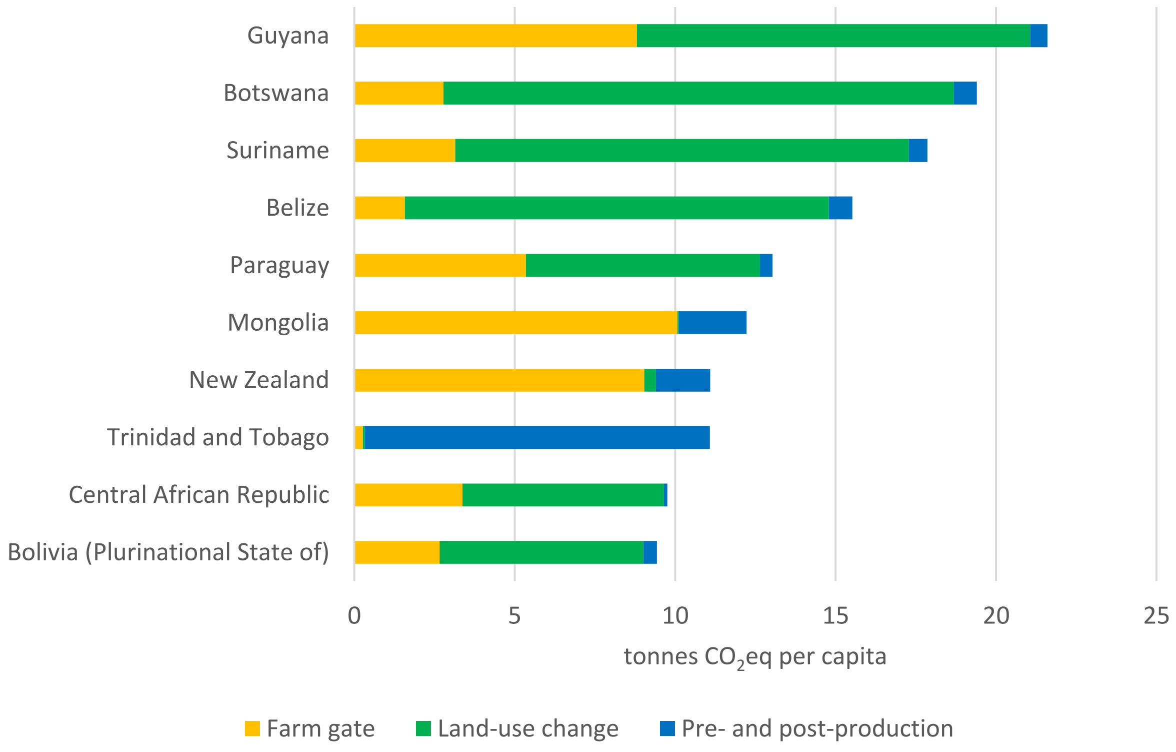


Source: FAO. 2022. Emissions intensities. In: *FAO*. Rome. Cited October 2022. https://www.fao.org/faostat/en/#data/EI

COUNTRY

In 2020, the ten countries with the highest agrifood systems emissions per capita had values five to ten times higher than the global average. Guyana led the ranking with over 20 t CO_2eq/capita, followed by Botswana, Suriname and Belize with 19 t CO_2eq/capita, 18 t CO_2eq/capita and 15 t CO_2eq/capita, respectively. Mongolia, Paraguay, Trinidad and Tobago, New Zealand and the Central African Republic had comparable values (10–13 t CO_2eq/capita). The Plurinational State of Bolivia closed the ranking with slightly more than 9 t CO_2eq/capita. Except for Mongolia and New Zealand, the top ten countries are mostly located in Latin America and the Caribbean, and Africa. The relative contributions of the three components of agrifood systems emissions differ between countries. Pre- and post-production emissions accounted for nearly all the emissions in Trinidad and Tobago. Farm-gate activities dominated agrifood systems emissions in Mongolia and New Zealand. While the land-use change component only had a marginal role in these three countries, it dominated agrifood systems emissions in Guyana, Botswana, Suriname, Belize, the Central African Republic and the Plurinational State of Bolivia (Figure 7).

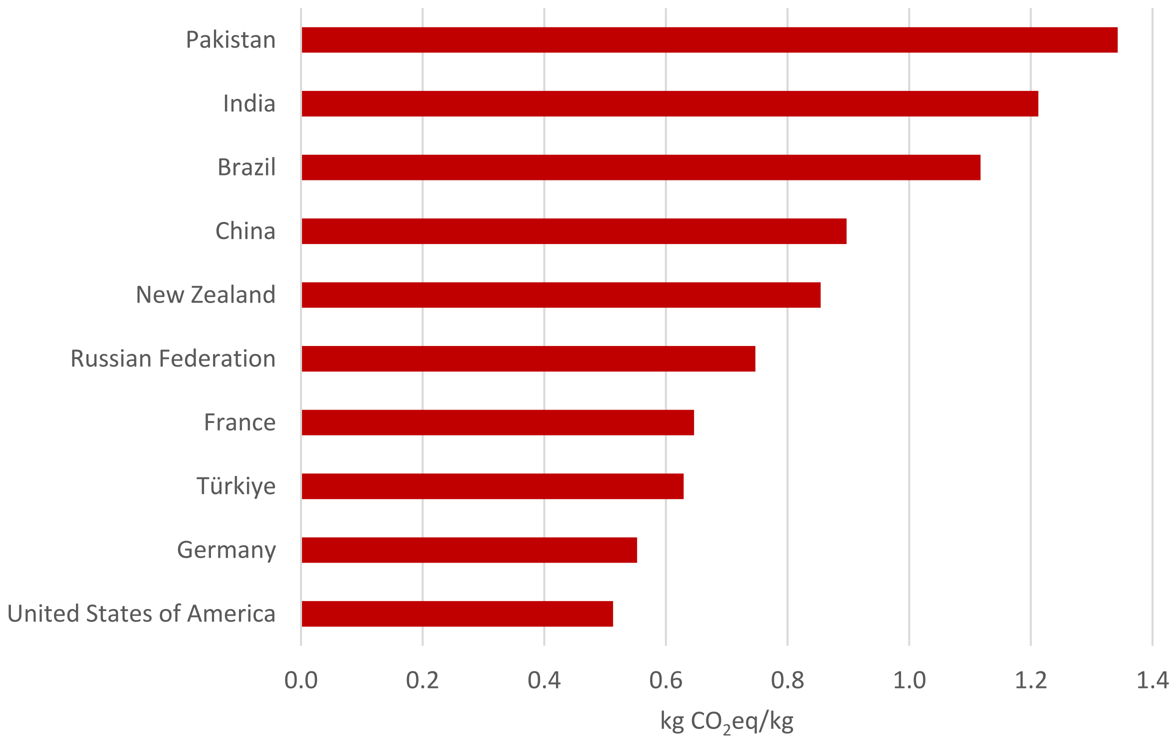
Figure 7: Agrifood systems emissions per capita, top countries (2020)



Source: FAO. 2022. Emissions shares. In: *FAO*. Rome. Cited October 2022. https://www.fao.org/faostat/en/#data/EM

Figure 8 illustrates the variability of the emissions intensity of cow milk among the world's top ten producers. In 2020, Pakistan, India and Brazil were the three large producers with the intensity of emissions higher than the global average (1 kg CO_2eq per kg of milk). At the opposite end, the United States of America and Germany had emissions intensities about half the global average, reflecting the prevalence of intensive and specialized production systems of cow milk in these countries. The emissions intensity of cow milk declined for all the top ten producers by 20 to 50 percent since 2000. The largest reductions were observed in Brazil, the Russian Federation and Türkiye, where the 2020 emissions intensity of cow milk was about half the intensity in 2000. In New Zealand and Pakistan, the reduction was instead more limited (-20 percent).

Figure 8: Emissions intensity of cow milk for the top ten producers (2020)



Source: FAO. 2022. Emissions intensities. In: *FAO*. Rome. Cited October 2022. https://www.fao.org/faostat/en/#data/EI

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 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 1961–2020 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 (1990–2020), savanna, forest fires and fires in organic soils (1990–2021).

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 1990–2020. 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 v2.3 (Gütschow and Pflüger, 2022).

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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