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The share of agri-food systems in total greenhouse gas emissions

Global, regional and country trends

1990–2019

>> FAO Statistics Division

HIGHLIGHTS

- → In 2019, global anthropogenic emissions were 54 billion tonnes of carbon dioxide equivalent (CO_2eq), of which 17 billion tonnes CO_2eq, or 31 percent, came from agri-food systems.
- → In terms of single gases, agri-food systems generated 21 percent of carbon dioxide emissions, 53 percent of methane emissions and 78 percent of nitrous oxide emissions globally in 2019.
- → Farm-gate emissions were the largest component of agri-food systems emissions in 2019 with roughly 7 billion tonnes CO_2eq, followed by pre- and post-production processes (6 billion tonnes CO_2eq) and land use change (4 billion tonnes CO_2eq).
- → Emissions from agri-food systems increased globally by 16 percent between 1990 and 2019, but their share in total emissions decreased, from 40 percent to 31 percent, as did the per capita emissions, from 2.7 to 2.1 tonnes CO_2eq per capita.
- → In 2019, the composition of agri-food systems emissions varied between developed and developing countries. Pre- and post-production processes accounted for more than half the total in developed countries, while in developing countries farm-gate activities and land use change dominated agri-food systems emissions.
- → In 2019, agri-food systems represented more than 70 percent of total anthropogenic emissions in Africa and South America, the highest among all regions.
- → In 2019, the countries with the largest emissions from agri-food systems were China, India, Brazil, the United States of America and Indonesia, though none of them figured as top emitters per capita.
- → Emissions from farm-gate activities and supply chains were the main drivers of food systems emissions in several developed and emerging economies, including the United States of America, China and India. Conversely, land use change was the largest component in Brazil and Indonesia.

FAOSTAT EMISSIONS SHARES

INTRODUCTION

Emissions from agri-food systems are those generated by farm production activities (crops and livestock), land use change and pre- and post-production processes. The first two components result in emissions generated on agricultural land, while the third refers to emissions from supply chain processes including transport, processing and input manufacturing, as well as from household consumption and waste. Emissions on agricultural land are well characterized in the literature, with the Food and Agriculture Organization of the United Nations (FAO) disseminating annual updates (FAO, 2021) that are widely used and inform the periodic assessments of the Intergovernmental Panel on Climate Change (IPPC). They include non-CO_2 emissions from crop and livestock production, generated within the farm gate, as well as carbon losses from land conversion processes needed to make room for new cultivations – mainly tropical deforestation and peatland degradation.

Conversely, the quantification of emissions generated in agri-food systems beyond the farm gate is a more recent endevour, with global estimates of the total share of food sytems in total anthropogenic emissions estimated at 27–39 percent (Rosenzweig *et al.*, 2020). Estimations of such emissions by country have only been produced very recently (Crippa *et al.*, 2021; Tubiello *et al.*, 2021a).

This analytical brief presents results of the first such database developed by FAO. Statistics on absolute emissions and their shares are disseminated at the country, regional and global level, over the period 1990–2019, in the FAOSTAT Emissions shares domain. The domain covers, in addition to emissions on agricultural land, pre- and post-production processes in agri-food systems, such as those linked to: i) the production of inputs (fertilizers, materials for food packaging); ii) energy generation and consumption in food supply chains (food processing, transport and retail) and at the household level (cooking and refrigeration); and iii) waste disposal (such as in landfilling, incineration and wastewater management). In order to quantify shares of agri-food systems emissions in the total economy, the FAOSTAT Emissions shares domain also includes information on emissions from all sectors, as classified by IPCC (2006) for use in country reporting to the United Nations Framework Convention on Climate Change (UNFCCC). These sectors include: agriculture, land use, land use change and forestry (LULUCF), energy, industrial processes and product use (IPPU), and waste.The database covers emissions from all sectors, for the three major trace gases – carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) – and fluorinated substances (F-gases), as well as their cumulative effects expressed in carbon dioxide equivalent (CO_2eq). Data are provided in both IPCC and FAO classifications, in support of multiple reporting processes needs and facilitating a range of analyses in relation to agri-food systems and emissions (Figure 1).

GLOBAL

In 2019, global anthropogenic greenhouse gas (GHG) emissions, from all economic sectors including LULUCF, totalled 54 billion tonnes CO_2eq (Gt CO_2eq) and 52 Gt CO_2eq without LULUCF emissions. The largest contributor to world total emissions was the energy sector, with a total share of 70 percent, due to the burning of fossil fuels. The next significant contributor to global emissions was the agriculture, forestry and other land use (AFOLU) sector, which combines IPCC sectors Agriculture and LULUCF, at 14 percent of total emissions. Industrial processes and product use were responsible for 9 percent of the total, and waste for 5 percent. The remainder was covered by other sectors, including international tranport.

Figure 1: Mapping of agri-food systems from IPCC to FAO categories

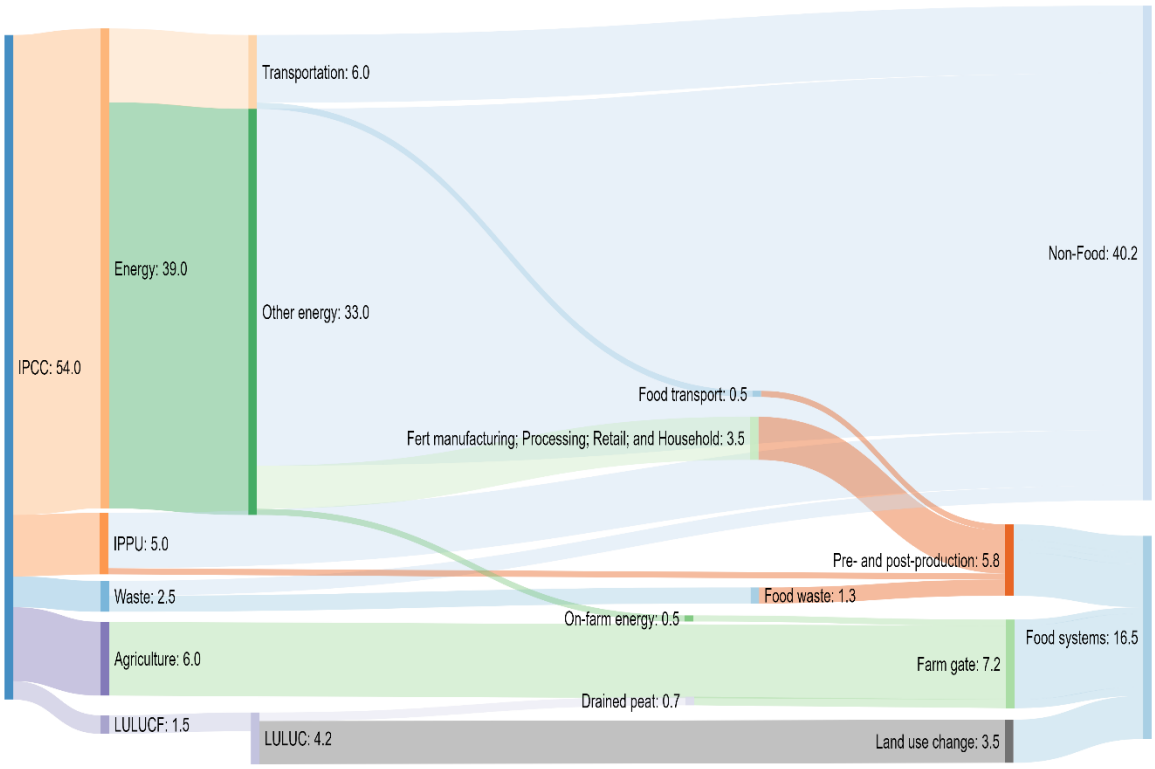
IPCC		Agri-food systems activity	GHG			FAO		
			CH_4	N_2O	CO_2			
AFOLU	LULUCF	Net forest conversion	x	x	x	LAND USE CHANGE	AGRICULTURAL LAND	AGRI-FOOD SYSTEMS
		Tropical forest fires	x	x	x			
		Peat fires	x		x			
		Drained organic soils	x		x	FARM GATE		
	AGRICULTURE	Burning – Crop residues	x	x				
		Burning – Savanna	x	x				
		Crop residues		x				
		Drained organic soils		x				
		Enteric fermentation	x					
		Manure management	x	x				
		Manure applied to soils		x				
		Manure left on pasture		x				
		Rice cultivation	x					
		Synthetic fertilizers		x				
ENERGY		On-farm energy use	x	x	x			
		Fertilizer manufacturing	x	x	x	PRE- AND POST-PRODUCTION		
		Processing	x	x	x			
		Packaging	x	x	x			
		Transport	x	x	x			
		Household consumption	x	x	x			
		Retail – Energy use	x	x	x			
INDUSTRY		Retail – Refrigeration	x	x	x			
WASTE		Solid food waste	x					
		Incineration			x			
		Industrial wastewater	x	x				
		Domestic wastewater	x	x				

Source: Tubiello *et al.*, 2021b.

Emissions from agri-food systems were 17 Gt CO_2eq (31 percent of total emissions), composed of 7.2 Gt CO_2eq (13 percent) from activities within the farm gate, 3.5 Gt CO_2eq (7 percent) from land use change processes such as deforestation and peatland degradation, and 5.8 Gt CO_2eq (11 percent) from pre- and post-production processes. For the latter, the largest contributors were methane emissions

from waste disposal (1.3 Gt CO_2eq) and CO_2 emissions from fossil fuel combustion for energy used in households (1.3 Gt CO_2eq), retail (0.9 Gt CO_2eq) and transport (0.5 Gt CO_2eq) (Figure 2).

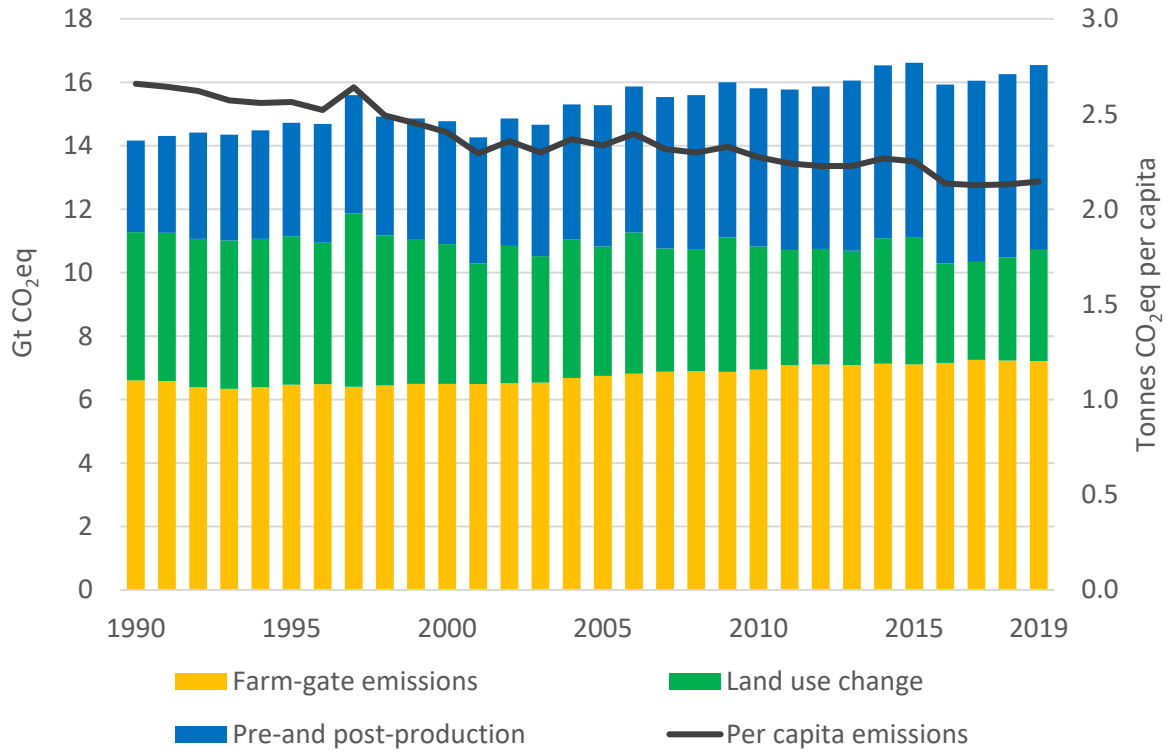
Figure 2: World total anthropogenic emissions flows from IPCC sectors to agri-food systems and non-food sectors, 2019 (Gt CO_2eq)



Source: FAO, 2021.

World total GHG emissions from agri-food systems increased by 16 percent between 1990 and 2019. Overt the same period, emissions per person decreased by over 25 percent, from 2.7 to 2.1 tonnes CO_2eq per capita (Figure 3).

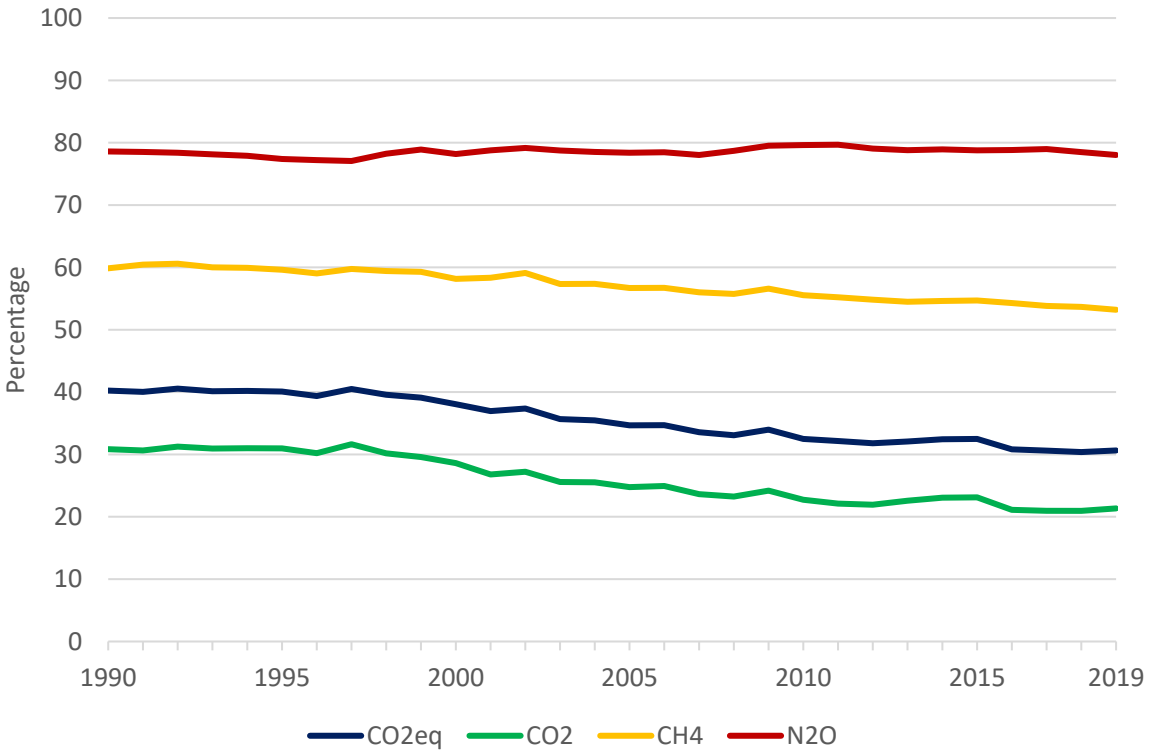
Figure 3: Global agri-food system GHG emissions by life-cycle stage, and per capita emissions



Source: FAO, 2021.

When breaking down agri-food systems emissions by GHG, CO_2 emissions increased between 1990 and 2019 from 7.6 to 8.4 Gt (+11 percent), CH_4 emissions from 171 to 195 Mt (+14 percent) and N_2O emissions from 6.8 to 8.6 Mt (+26 percent). At the same time, the share of agri-food systems in total anthropogenic emissions decreased, from about 40 percent to 31 percent when measured in CO_2eq. This corresponds to decreases from 31 to 21 percent of the total for CO_2 and from 60 to 53 percent for CH_4, while it remained at around 80 percent for N_2O over the entire period (Figure 4).

Figure 4: Global agri-food systems GHG emissions shares by gas



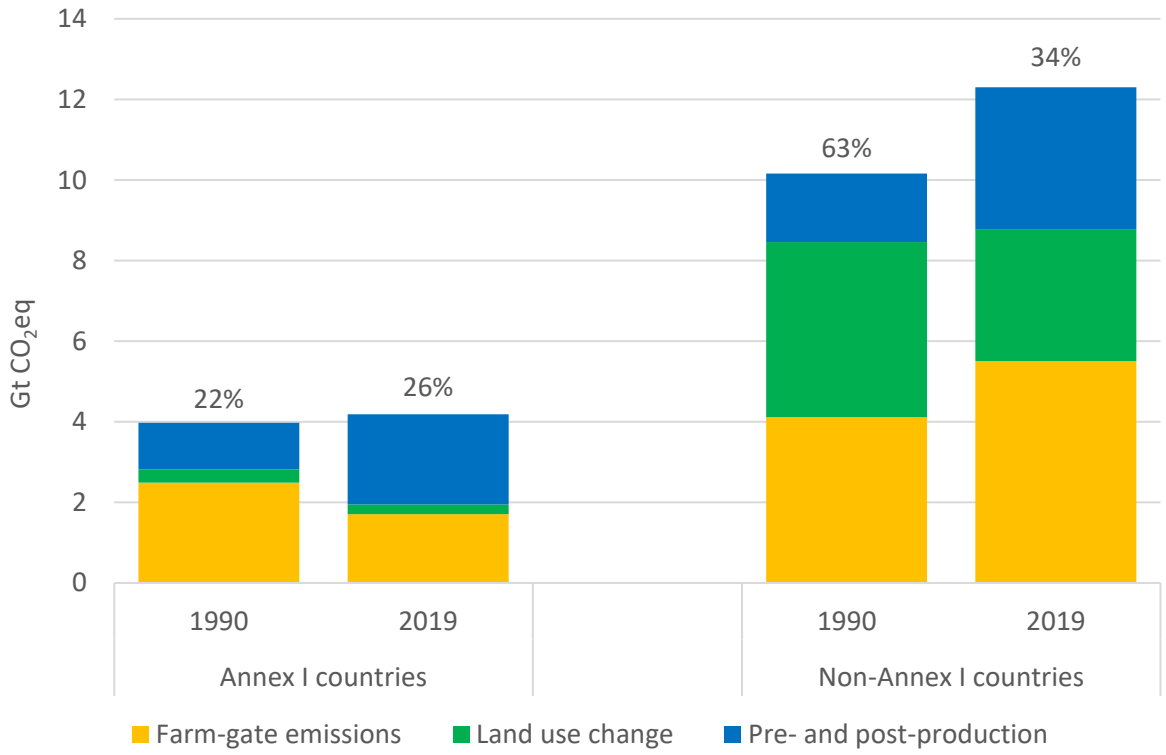
Source: FAO, 2021.

SPECIAL GROUPS AND REGIONS

Examining agri-food systems GHG emissions by Annex I and Non-Annex I country groupings can reveal trends across development contexts, as countries listed in Annex I of the UNFCCC can be used as a proxy to understand trends in developed economies, while the non-Annex I country grouping can be used as a proxy to examine trends in developing economies. A full listing of countries within each group can be found in FAOSTAT (FAO, 2021).

Total agri-food systems increased across both country groupings, from 3.9 Gt CO_2eq in 1990 to 4.2 Gt CO_2eq in 2019 in Annex I countries (a 5 percent increase), and from 10.2 Gt CO_2eq in 1990 to 12.3 Gt CO_2eq in 2019 in Non-Annex I countries (a notable 21 percent increase) (Figure 5). In addition, clear trends can be identified across life-cycle stages: both country groups have significantly increased GHG emissions from pre- and post-production and reduced land-use emissions over the period 1990–2019, while a divergent trend can be observed for on-farm emissions, largely driven by agricultural emissions, i.e. those within the farm gate and due to related land use change (Figure 6).

Figure 5: Agri-food systems GHG emissions by life-cycle stage



Note: The percentages indicate the share of agri-food systems in the total emissions of the region.

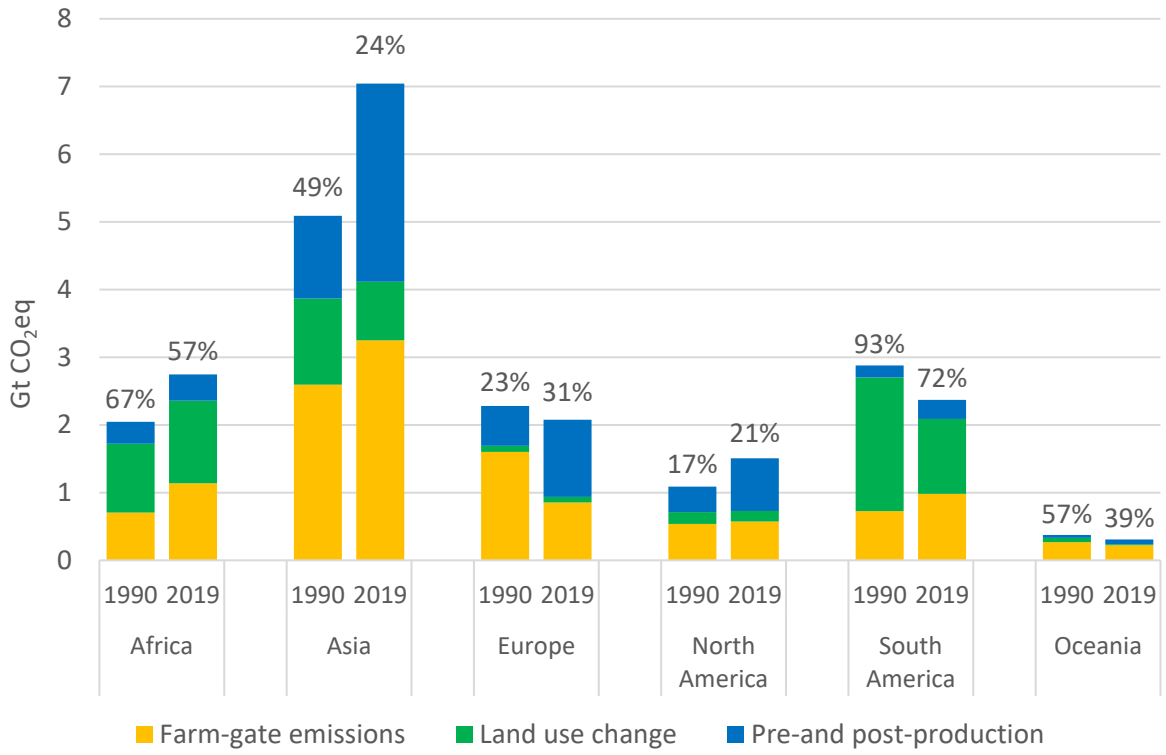
Source: FAO, 2021.

In 2019, the *relative* contribution of agri-food systems to regional total emissions from all human activities was the largest in Africa and Latin America, with a share of 56–72 percent, while it was nearly 24 percent in Asia and North America.

Land use emissions dominated the large shares in Africa and Latin America, and were larger than farm-gate emissions and pre- and post-production emissions. Farm-gate emissions were nonetheless significant in these two regions, as well as in Oceania (above 38 percent). In Europe, emissions from pre- and post-production activities represented 17 percent of the total in 2019, compared to 8–10 percent in Oceania, Asia and North America.

The top two *absolute* emitters in 2019 were Asia and Africa, and in these regions, the share of land-use change emissions decreased significantly since the 1990s (from 33 to 26 percent in Africa; and 12 to 3 percent in Asia), while the share of emissions from pre- and post-production decreased only slightly (from 10 to 8 percent in Africa; and 12 to 10 percent in Asia).

Figure 6: Agri-food systems emissions by region and life-cycle stage



Note: The percentages indicate the share of agri-food systems in the total emissions of the region.

Source: FAO, 2021.

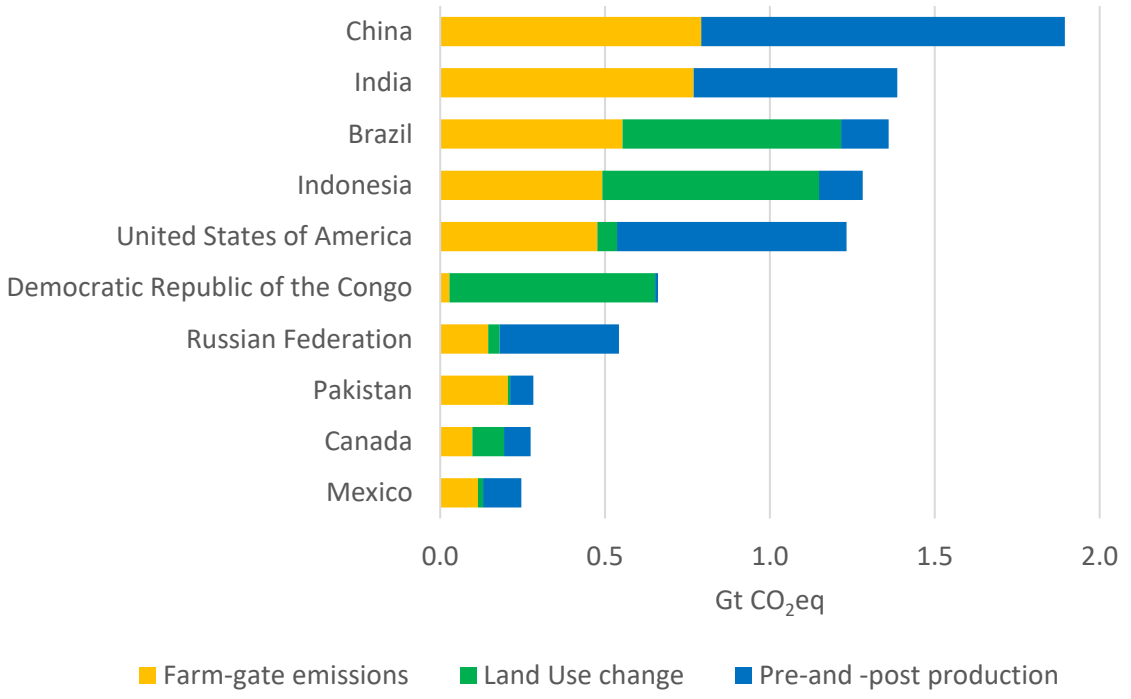
COUNTRY

In 2019, the contribution of agri-food systems to total emissions was above 90 percent in 9 countries, including Eswatini, Ghana, the Central African Republic, Rwanda, the Democratic Republic of the Congo, Chad, Fiji, Paraguay and Belize. In 2019, shares of emissions from farm-gate activities above 70 percent were reported in five countries and territories, including Mali, the Niger, Mauritania, Chad and South Sudan.

China, India, Brazil, the United States of America and Indonesia have the largest absolute emissions from agri-food systems, each contributing more than 1 Gt CO_2eq (Figure 7). For the top five emitters, the respective shares of agri-food systems emissions in the total in 2019 were 14 percent for China, 36 percent for India, 83 percent for Brazil, 20 percent for the United States and 62 percent for Indonesia.

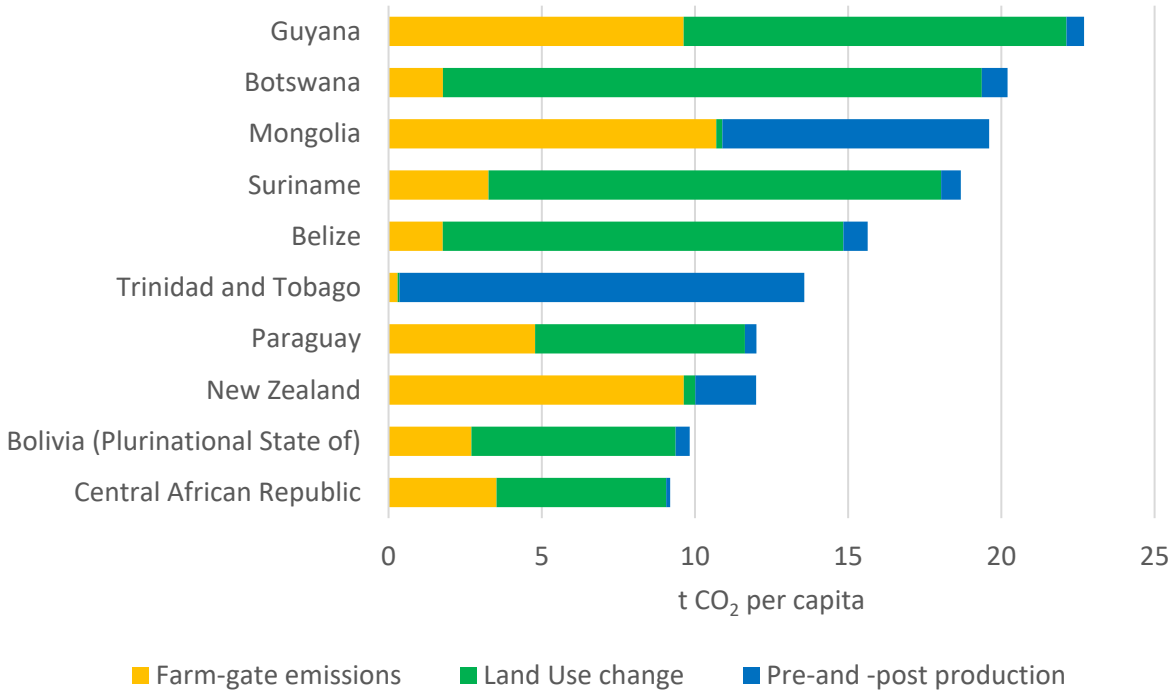
A different set of countries dominate per capita emissions with Guyana and Botswana leading with over 20 tonnes CO_2eq emissions per capita (Figure 8), which is more than 20 times the global agri-food systems per capita emissions.

Figure 7: Agri-food systems emissions, top countries (2019)



Source: FAO, 2021.

Figure 8: Agri-food systems emissions per capita, top countries (2019)



Source: FAO, 2021.

EXPLANATORY NOTES

- The FAOSTAT Emissions shares domain disseminates data on the greenhouse gas emissions shares of agri-food systems, including land use, land-use change and forestry, to the total emissions from all economic sectors, by gas, country and year, for the period 1990–2019. Total emissions are also disseminated for transparency. The economic sectors considered as emission sources are those defined by the Intergovernmental Panel on Climate Change in the 2006 guidelines (Vol.1, ch.8): energy, industrial processes and product use, waste, and agriculture, including their food-related shares. Agriculture-related land use emissions are calculated in accordance to IPCC (2019).
- Emissions estimates from the FAOSTAT domain 'Emissions Total' are the source for 'IPCC Agriculture', 'LULUCF', 'Farm-gate emissions' and the FAOSTAT domain 'Energy use' is the source 'On-farm electricity use' and on-farm fuel burning emissions included in 'Farm-gate emissions'. Emissions for LULUCF are those associated with the carbon losses due to forest converted to other land uses (net forest conversion); the degradation of organic soils used for cultivation and grazing; and the emissions from biomass burnt in humid tropical forests and in organic soils, including CO_2 emissions and removals from carbon stock changes in the biomass pools of 'Forest land' and the emissions from the burning of biomass in sub-tropical, temperate and boreal forests. Farm-gate emissions include emissions associated with IPCC Agriculture and fuel consumption on-farm. The PRIMAP-hist national historical emissions time series v2.3 is the source of CO_2, CH_4, N_2O and F-gases emissions for the sectors Energy, IPPU, Waste and Other. PRIMAP-hist is developed and maintained by the Potsdam Institute for Climate Impact Research (Gütschow *et al.*, 2016; Gütschow *et al.*, 2021). In preparation of this domain, the third-party data scenario of PRIMAP-hist v2.3 was used (Gütschow *et al.*, 2021). The PRIMAP categories correspond to the IPCC 2006 categories for emissions. PRIMAP combines several databases to produce the emissions data for each country covering the years 1850 to 2019. Information for the sector "International bunkers" is available in the domain as a global aggregate and derived from data on 'International aviation' and 'International navigation/shipping' of the EDGAR v6.0 dataset (Crippa *et al.*, 2021), covering the period 1990–2018. Values for 2019 were computed using a 2-year moving average function. Emissions on agri-food system-related activities of each IPCC sector were compiled by FAO based on several sources (UNSD Energy Statistics Database; UNSD Industrial Commodity Statistics; FAOSTAT Forestry Production and Trade; FAOSTAT Fertilizers by Products; IEA Energy Statistics; EDGAR-FOOD; EDGAR v6.0; World Bank and IPCC waste data, according to new FAO methodology (Karl and Tubiello, 2021a and 2021b; Tubiello *et al.*, 2021b).
- The domain 'Emissions shares' contains the following data categories available for download by sector, country and year: a) shares of total CO_2eq emissions; b) shares of total CO_2, CH_4, N_2O and and fluorinated gases (F-gases, including hydrofluorocarbons (HFCs), perfluorinated compounds (PFCs), SF_6 and NF_3 gases; c) emissions in thousand tonnes CO_2eq; d) emissions in thousand tonnes of the single gases.
- Data are available for 194 countries and 38 areas/territories over the period 1990–2019. Data are also disseminated for regional aggregates and special groups, such as the Annex I and Non-Annex I Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

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This analytical brief was prepared by Francesco N. Tubiello, Alessandro Flammini, Kevin Karl and Griffiths Obli Laryea, with inputs from Giulia Conchedda and Olivier Lavagne d'Ortigue.

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CONTACTS

Statistics Division – Economic and Social Development
statistics@fao.org
www.fao.org/food-agriculture-statistics/en/
Food and Agriculture Organization of the United Nations
Rome, Italy

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