

CLIMATE CHANGE



Global levels rise, while national levels fall



Greenhouse gas emissions are increasing worldwide but are decreasing in Brazil because of reduced deforestation in the Amazon

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Global greenhouse gas (GHG) emissions reached a record high in 2023, at 57.1 billion tons of carbon dioxide equivalent (CO₂eq). The figure is 1.3% higher than that in the previous year, according to a report released by the United Nations Environment Programme (UNEP) at the end of October. The growth rate was higher than that over the previous decade (from 2010 to 2019), when, before the outbreak of COVID-19, emissions increased by an annual average of 0.8%. In 2020, at the height of the pandemic, the suspension of many activities worldwide caused a decrease of almost 5% in the total emissions, the largest decrease recorded since the 1970s.

This year, global emissions increased in four of the five major GHG-producing sectors: energy, industrial processes, agriculture, and waste treatment. Only the land use, land-use change, and forestry (LULUCF) category exhibited the release of lower greenhouse gas emissions in 2023 than those in the previous year. The process most notably influencing the total emissions of this sector is the removal of vegetation, especially the clearing of forests, to create space for agriculture and livestock.

“The problem in Brazil is that the national inventory underestimates carbon dioxide emissions from forest fires and degradation in vegetation,” noted Luciana Gatti, head of the Greenhouse Gas Laboratory (LaGEE) of the Brazilian National

Institute for Space Research (INPE). Apart from agriculture, in which carbon can be stored in soil (its removal is not usually accounted for in carbon inventories), the LULUCF sector is the only sector that, in addition to producing emissions, can also naturally remove carbon dioxide from the air (other sectors only emit GHGs).

Well-preserved green areas can remove more CO₂ from the atmosphere via photosynthesis, thereby storing carbon in biomass, than they emit through respiration. Owing to its dense tropical vegetation, the Amazon has always been considered an area of the planet that absorbs more carbon than it emits. Recent studies, such as the research of Gatti’s team, have indicated that, owing to deforestation and progressive degradation, parts of the Amazon are losing the capacity to provide this ecosystem service that reduces global warming.

Today, most analyses indicate that the global temperature is at least 1.2 °C higher than the reference values during the preindustrial era in the second half of the nineteenth century. Various studies have revealed that this level of warming has led to deterioration in some of the planet’s vital signs, such as rising sea levels and the intensification of extreme weather events. Since 2023, however, a global temperature increase of 1.5 °C has been recorded several months in a row, although it is still considered a temporary increase.

According to the UNEP report, there has been an increase in the emission of four gases that con-

tribute to global temperature increase: carbon dioxide (CO₂), which alone causes three-quarters of the total global warming, driven primarily by the burning of fossil fuels (oil, gas, and coal); methane (CH₄), which is released mainly through agriculture and leakage during natural gas exploration; nitrous oxide (N₂O), which is present in agricultural fertilizers and animal waste; and hydrofluorocarbons (HFCs), which are used in refrigeration systems.

In statistics, the emissions of methane, nitrous oxide, and HFCs are commonly converted into their equivalents in CO₂. The established conversion equation indicates that in one century, the production of one ton of methane or nitrous oxide heats the atmosphere to the same extent as that due to 25 or 298 tons of CO₂, respectively. For HFCs, which encompass a family of artificially produced gases, the conversion factor often exceeds one thousand.

If the current upward trend in GHG emissions is not reversed, there is zero chance of limiting global warming to 1.5 °C, i.e., the target established by the Paris Agreement in 2015, and the global temperature will increase by an estimated 2.5 °C to 3 °C by the end of the century. This level of warming would be catastrophic, resulting in a very high cost to human life and the global economy. “To achieve a least-cost pathway toward [limiting global warming to] 1.5 °C, emissions must fall 42% by 2030 compared with 2019 levels,” Danish economist Inger Andersen, UNEP’s executive director, said in the document’s foreword. Another way would be to reduce emissions by 7.5% every year from now until 2035.

EMISSIONS IN BRAZIL DECREASE

Unlike most of the planet, GHG emissions in Brazil significantly decreased last year. According to the Greenhouse Gas Emissions and Removals Estimation System (SEEG), which is managed

by a network of nongovernmental organizations known as the Climate Observatory, the country emitted 2.6 billion gross tons (not including removal) of CO₂eq into the atmosphere in 2023, which is 12% less than that in 2022. It was the largest decrease over the last 15 years.

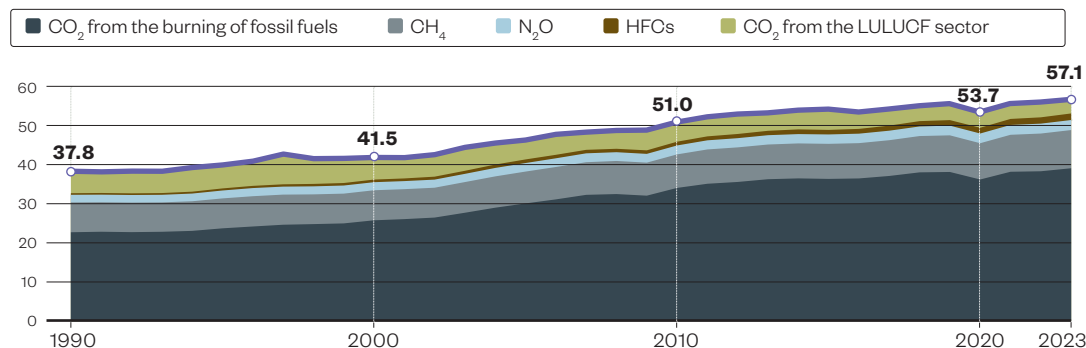
The sector that contributed most to the country’s emissions was land-use change (46%), historically the leader in GHG production in Brazil, followed by agriculture (28%), energy (18%), waste management (4%), and industrial processes (4%). With respect to net emissions (the gross total emissions minus the carbon removed from the atmosphere through the photosynthesis of growing vegetation), the amount of GHGs released into the atmosphere by Brazil in 2023 was approximately 1.6 billion tons of CO₂eq.

The data from SEEG are not official, but they closely follow the methodology recommended by the United Nations Intergovernmental Panel on Climate Change (IPCC). “By the end of this year, we will create a new inventory of net greenhouse gas emissions [considering removal by the LULUCF sector] up to the period of 2022,” said Márcio Rojas, head of climate science and sustainability at the Brazilian Ministry of Science, Technology, and Innovation (MCTI). “Our numbers are usually very similar to the net emission figures calculated by SEEG, which uses the national inventory as a reference.”

The most recent information from the ministry’s National Emissions Registration System (SIRENE) pertains to 2020, the year the pandemic began. Brazil emitted 1.7 billion tons of CO₂eq that year, 38% of which stemmed from the LULUCF sector and 28.5% stemmed from agriculture, according to SIRENE. The energy, industrial processes, and waste management sectors accounted for 23.2%, 6.1%, and 4.2%, respectively, of the total GHG emissions.

All the greenhouse gases

Global emissions of carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons (billions of tons of CO₂eq)



SOURCE UNEP EMISSIONS GAP REPORT 2024



The reduction in emissions in Brazil in 2023 was due to the particular nature of its economic model. The country's total GHG output was lower last year owing exclusively to a 24% decrease in emissions from the land-use change sector. In the other four sectors that release carbon into the atmosphere (energy, agriculture, industrial processes, and waste management), emissions increased in Brazil in 2023, according to SEEG. "In Brazil, land-use change has historically dictated the dominant trend in the production of greenhouse gases," explained David Tsai, a chemical engineer from the Institute for Energy and the Environment (IEMA) and coordinator of SEEG. "It serves as a kind of modulator, a regulator of the intensity of the total emissions."

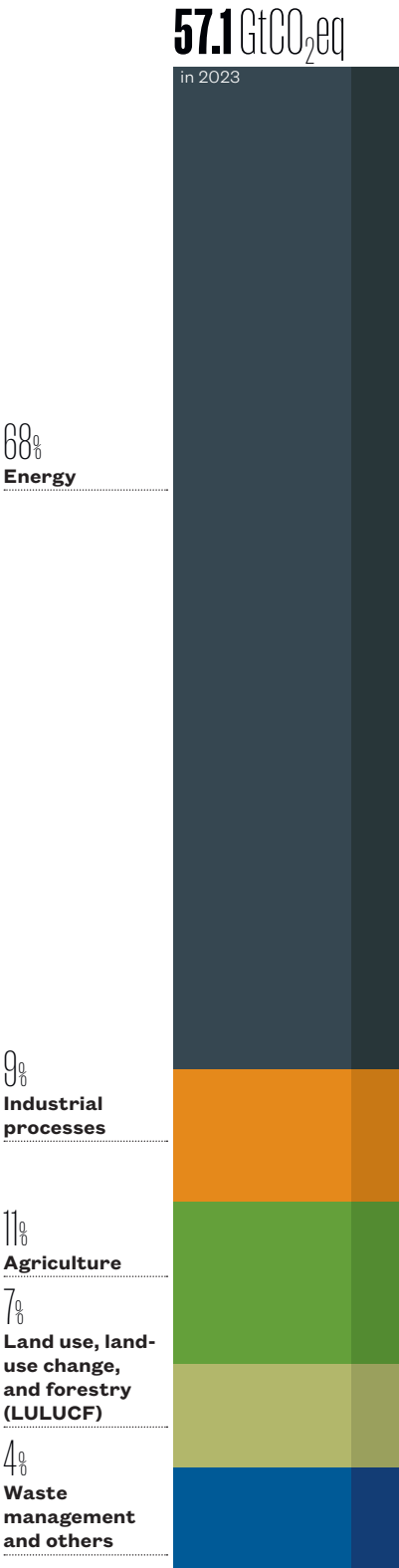
Among the major countries and blocs that currently emit the most GHGs into the atmosphere, such as China (30% of the total emissions), the USA (11%), India (8%), the European Union (6%), and Russia (5%), the sector that accounts for most of the greenhouse gas emissions is, by far, energy. Despite recent advances in the use of wind and solar energy, the energy mix in these countries still relies heavily on the consumption of oil, gas, and coal. Thus, in these areas and globally, the burning of fossil fuels is still the major driver of global warming. The USA has emitted the most GHGs since the mid-nineteenth century, accounting for approximately 20% of the total GHGs since 1850.

Brazil has a cleaner energy mix than other countries do. More than 80% of its electricity originates from renewable sources, such as hydroelectric, solar, and wind power plants, and a significant proportion of the country's vehicles run on biofuel. Despite this fact, depending on the year and the source consulted, the country is still the fifth or sixth largest emitter at present, accounting for 2% or 3%, respectively, of the total GHG emissions. As a global leader in crop and cattle farming, the country produces a large volume of GHGs through agriculture. In Brazil, this sector plays a greater role in determining the total emissions than that in most other major economies.

Tsai noted that a significant change in a single parameter in the land-use change sector was responsible for the decrease in the total GHG emissions in the country in 2023: a significant decrease in deforestation in the Amazon, the largest tropical forest on the planet, 60% of which is located in Brazil. Approximately 4,500 square kilometers (km²) of the biome was deforested in the Brazilian territory in 2023, 62% less than in the previous

Influence of each sector

Sectors that produced the highest greenhouse gas emissions worldwide in 2023 (as a percentage of the total emissions)

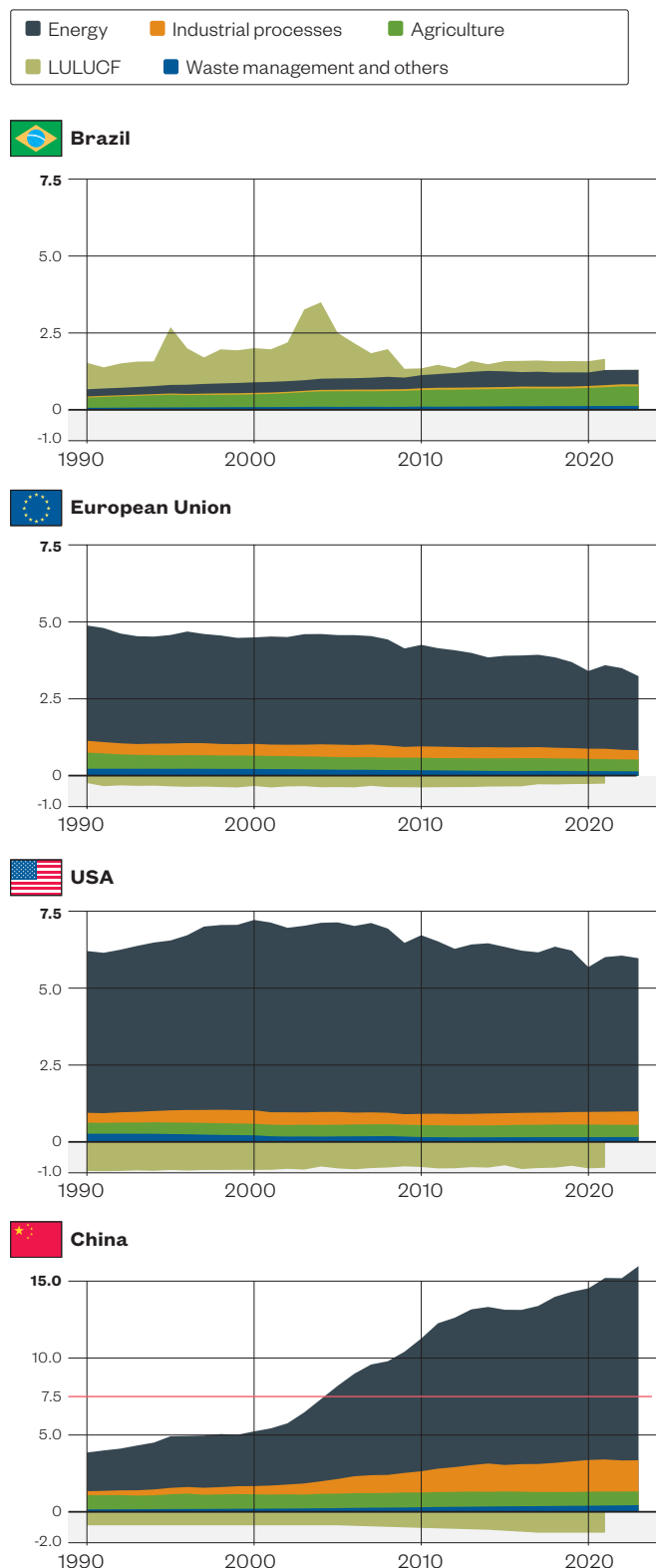


The total does not add up to 100% because not all sources of GHGs are known
SOURCE UNEP EMISSIONS GAP REPORT 2024

Emission profile by country

The energy sector is the largest producer of greenhouse gases in most major economies; in Brazil, the main producing sectors have historically been the agriculture and LULUCF sectors

IN BILLIONS OF TONS OF CO₂EQ



SOURCE UNEP EMISSIONS GAP REPORT 2024

year, according to a report issued by MapBiomass, another Climate Observatory initiative.

The official data used by the Brazilian government in international negotiations also suggest a recent and significant decrease in deforestation in the “Legal Amazon,” a political and administrative concept that encompasses almost 60% of Brazil’s territory, including the entire Amazon biome, 20% of the Cerrado (a wooded savanna biome), and a small area of the Pantanal. According to information released in early November by the Brazilian Amazon Deforestation Satellite Monitoring Program (PRODES), a project managed by INPE, 6,288 km² of the Legal Amazon was deforested in 2024, 31% less than in the previous year.

“Deforestation trends, especially in the Amazon, exert a major impact on the profile and volume of greenhouse gas emissions,” noted Rojas from the MCTI. Data from MapBiomass and PRODES generally indicate the same major trend with regard to deforestation in the Amazon, although they cannot be compared directly owing to methodological differences.

The cleaner energy mix and the notable influence of deforestation and agriculture on the total emissions make Brazil a unique country in the international landscape of greenhouse gas production. Approximately three-quarters of emissions in the world’s largest economies results from activities and processes that depend on the burning of fossil fuels. In China, the USA, and the European Union, the LULUCF sector (and even agriculture) generally exerts a lower influence on the total amount of carbon emitted into the atmosphere.

During the 2024 United Nations Climate Change Conference (COP29), held in Baku, Azerbaijan, between November 11 and 22, Brazil announced a new commitment to reduce emissions from 2030 to 2035. Referred to as the nationally determined contribution (NDC), Brazil’s target for 2035 is to reduce its net greenhouse gas emissions (considering carbon removal through forest maintenance) to between 59% and 67% of 2005 levels. In numerical terms, this would amount to a reduction in emissions in Brazil to between 850 million and 1.05 billion tons of CO₂eq per year.

The new NDC, one of the commitments required from all 196 signatory countries of the Paris Climate Agreement as part of the effort to limit global warming to 1.5 °C, was considered complacent by many environmentalists. This opinion is not shared by Roberto Schaeffer, an engineer from the Alberto Luiz Coimbra Institute



for Engineering Research and Graduate Studies at the University of Rio de Janeiro (COPPE-UFRJ). “The goal is very ambitious,” said Schaeffer, a professor in UFRJ’s energy planning program, whose team conducted the studies (not yet published) supporting the new NDC target at the request of the Brazilian government. “If we eliminate deforestation, emissions from the LULUCF sector will plummet rapidly, as will the country’s total GHG emissions. When this happens, Brazil’s emission profile will become more similar to those of other countries. From then on, we will also have to try even harder to reduce emissions from sectors other than the LULUCF sector alone while simultaneously encouraging GHG removal through the preservation and restoration of forests.”

Once this new hypothetical scenario is established, Brazil would exhibit a smaller carbon footprint, but it would also find it more difficult

to continue drastically cutting its emissions. The reason is that the four other major sectors that produce GHGs (energy, agriculture, industrial processes, and waste management) respond much more slowly to changes designed to reduce emissions. “Methane production by cattle, for example, will not decrease radically overnight, even if it is possible to partly reduce emissions resulting from enteric fermentation in livestock,” explained Schaeffer.

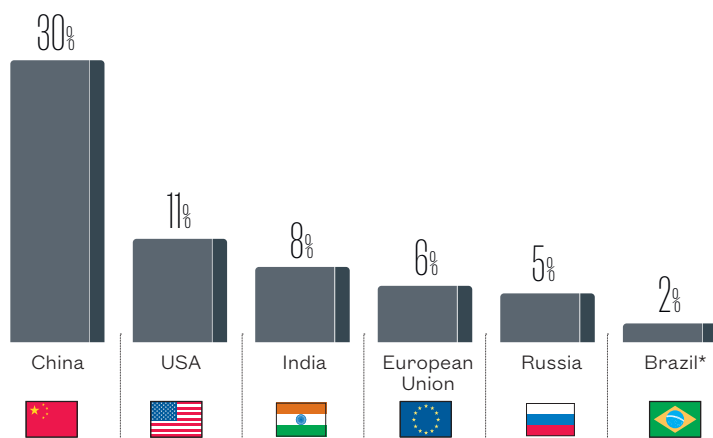
It is still too early to obtain global GHG emission data for 2024. However, the Global Carbon Budget (GCB), published annually since 2006, was released in November (not yet published in a scientific journal), providing an estimate of the year’s emissions of CO₂ alone, not including other GHGs. The figures outlined in the 2024 GCB, often employed as a reference, are cause for concern. The total carbon dioxide emissions are projected to set a new record of 41.6 gigatons by the end of December, 2.4% more than that in 2023.

Severe droughts caused by the El Niño climate phenomenon in 2023 and 2024, one of which still impacts the Amazon, have exacerbated emissions from deforestation and forest fires that cause vegetation degradation. “The impacts of climate change are becoming increasingly dramatic. However, we still see no sign that the burning of fossil fuels has peaked,” said Pierre Friedlingstein, from the University of Exeter, UK, in a press release.

In the Brazilian Amazon, deforestation continued to decrease this year. However, the number of forest fires in several biomes was very high, especially in the first half of the year, a period when few fires normally occur. Owing to this situation in Brazil, in addition to the global trend of continuously increasing emissions at a time when countries should reduce their carbon footprint—as promised in previous NDCs—optimism is currently low. However, giving up is not an option. We only have one habitable planet. ●

Largest emitters

The contribution of each country and bloc to the global greenhouse gas production in 2023



*The data are underestimated as emissions from land-use change are not accounted for
SOURCE UNEP EMISSIONS GAP REPORT 2024