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A Comparative Analysis of Greenhouse Gas Emissions by Developed and Developing Countries Since 1850

Jonathan Beynon, Ed Wickstead, and Tom Veale

Abstract

This paper aims to inform discussions on historical responsibility for climate change by presenting a comparative analysis of historical emissions from numerous datasets, using different measures of emissions, different classifications of developed and developing countries, and covering different time periods. We find that while the various datasets give significantly different estimates of total emissions, they are reasonably consistent in their estimates of developed country shares; that developed countries using the UNFCCC's Annex I classification are responsible for about half of all GHG emissions since 1850, and less than 40 percent if limited to the 23 Annex II countries with a formal obligation to provide climate finance. These shares are lower if we consider contributions to global warming rather than GHG emissions, much lower if we only consider emissions since 1990, but higher if we restrict analysis to just CO_2. We also find that taking account of colonial or consumption emissions makes relatively little difference to our results, and that developed country shares of cumulative per capita emissions (not that we think this is an appropriate measure) are even lower than for cumulative emissions.

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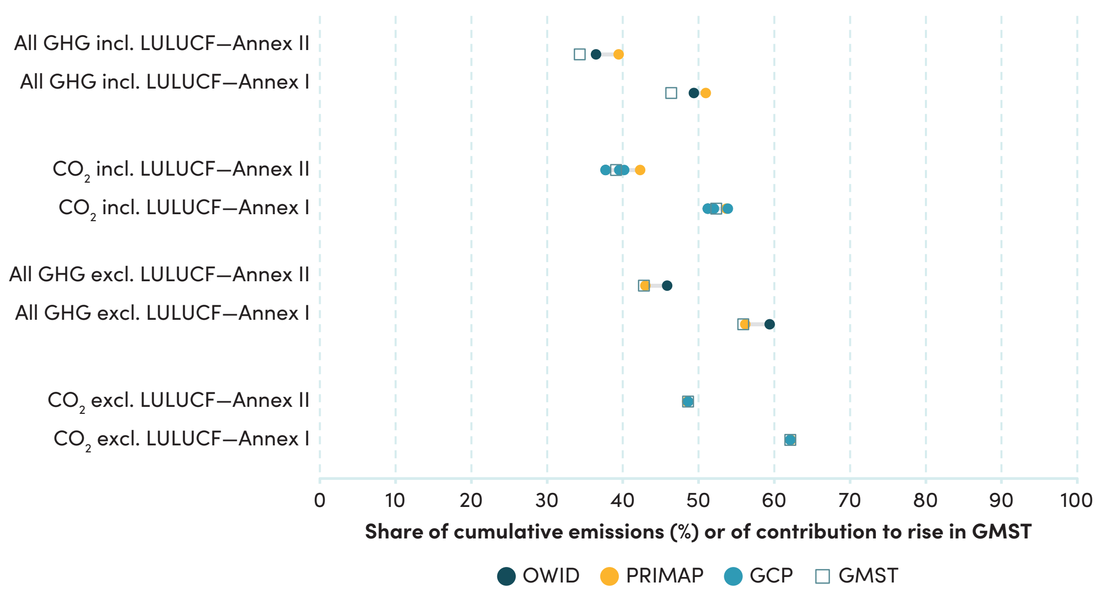
Executive summary

Questions about which countries are responsible for greenhouse gas (GHG) emissions lie at the heart of many discussions and negotiations on climate change. But counting GHG emissions is not straightforward. Assigning responsibility for climate change even less so. This paper presents a comparative analysis of historical GHG emissions from numerous datasets, using different measures of emissions, different classifications of developed and developing countries, and covering different time periods. We also consider colonial, consumption, and per capita emissions.

We find significant differences in aggregate emissions estimates across datasets. Estimates can vary by over 30 percent, with differences typically largest for measures that include land use, land use change, and forestry (LULUCF). Nevertheless, different datasets are much more consistent in their estimates of developed and developing country *shares* of those emissions.

Developed countries using the broadest definition (the 42 countries defined as Annex I by the UNFCCC) are responsible for about half of all GHG emissions (including LULUCF) from 1850–2024, with estimates ranging from 49–51 percent. Figures for the subset of 23 Annex II developed countries with a formal obligation to provide climate finance range from 36–39 percent. Alternative estimates of contributions to rises in global mean surface temperature (GMST), which account for the short-lived nature of some GHGs such as methane and are arguably a better reflection of contributions to global warming, are a little lower at 46 percent and 34 percent, respectively. But shares are higher if analysis is restricted to CO_2, and higher again if LULUCF emissions (around which there is greater uncertainty) are excluded, with Annex I and II shares of CO_2 excluding LULUCF being 62 percent and 49 percent, respectively (see Figure ES1).

FIGURE ES1. Shares of emissions and of contributions to increased GMST, 1850–2024



Taking the period since 1990, when the first IPCC report was published and for which more datasets are available, Annex I and II shares of all GHGs including LULUCF are significantly lower at 36–39 percent and 29–32 percent, respectively, with shares of contributions to rises in GMST of 33 percent and 25 percent, respectively. Once again, shares are higher if analysis is restricted to CO_2 and excludes LULUCF, with Annex I and II shares of 46–48 percent and 35–37 percent, respectively. These 1990–2024 shares are lower because around 40–45 percent of all GHG emissions have been produced since 1990, with emissions falling in most developed countries while rising rapidly in many emerging economies, reflecting the extraordinary economic progress that many have made.

The paper also considers three other factors that are often raised when debating country contributions to GHG emissions and responsibility for climate change. These concern colonial, consumption, and per capita emissions.

Taking account of colonial emissions makes a significant difference to some individual countries, but not that much difference to the overall picture. We find that even if *all* emissions from colonies are attributed to the respective colonial power during the period of occupation (arguably an equally unreasonable position), Annex I and II shares of all GHG emissions since 1850 rise by about 5 percentage points to 55–56 percent and 41–44 percent respectively, and by at most 1 percent for the measure focusing on CO_2 excluding LULUCF (to 63 and 49 percent respectively).

A focus on consumption rather than territorial emissions is constrained by data which is generally limited to the period since 1990 and only covers CO_2, but other analysis reviewed in this paper suggests that doing so would only add 2–3 percentage points to developed country shares, and possibly not much more even going back to 1850.

Per capita emissions feature prominently in discussions of equity and justice. We conclude, however, that cumulative per capita emissions is an inappropriate measure for assessing historical responsibility for climate change, particularly in the context of discussing country climate finance obligations, because it takes no account of population size. But even if we were to use this measure, we find that developed country shares of cumulative *per capita* emissions are typically 10–20 percentage points *lower* than for cumulative *aggregate* emissions using three different calculation methods over the period 1850–2024, and typically 5–15 percentage points lower over the period 1990–2024. This result arises because aggregations of per capita emissions are dependent on not just the level of emissions, but also the number of countries in the group. This illustrates the difficulties of using and interpreting data on cumulative per capita emissions, and reinforces the case for focusing on shares of aggregate emissions, although important ethical questions regarding per capita emissions remain.

These findings suggest that developed country shares of cumulative emissions and responsibility for climate change are significantly lower than widely perceived. Many may find these results surprising and contentious, but we hope that this analysis will inform ongoing discussions about historical emissions and their implications for the provision of climate finance.

Introduction

It is widely believed that developed countries are primarily responsible for causing climate change because of their much larger emissions of greenhouse gases (GHGs).[1] But is this assumption correct? Counting GHG emissions is not straightforward and assigning responsibility for climate change even less so. Results are sensitive to the measure of emissions, the definition of "developed" countries, and the choice of data source.

This paper explores this sensitivity by reviewing all the major emissions datasets. We first present some key information on the sources of emissions, discuss some of the methodological challenges in compiling emissions data, and summarise the key features and differences in the most widely used sources. We then present a comparative analysis of historical emissions from these different datasets, using different measures of emissions, different classifications of developed and developing countries and covering different time periods. To our knowledge, this has not been done before. We also address debates around colonial, consumption, and per capita emissions, which many have argued place even more responsibility on developed countries.

We find that while the various datasets differ widely in their estimates of total emissions, they are reasonably consistent in their estimates of developed country shares; that developed countries (using the United Nations Framework Convention on Climate Change (UNFCCC) Annex I category) are responsible for about half of all GHG emissions since 1850, but less than 40 percent if limited to the 23 Annex II countries with a formal obligation to provide climate finance; that these shares are even lower if we consider contributions to global warming rather than GHG emissions, much lower if we only consider emissions since 1990, but higher if we restrict analysis to just CO_2; that taking account of colonial or consumption emissions makes relatively little difference to our results; and that developed country shares of cumulative per capita emissions (not that we think this is an appropriate measure) are even lower than for cumulative emissions using three different calculation methods. But some important ethical questions regarding per capita emissions remain outstanding.

1 As demonstrated by a straw poll of dozens of colleagues and contacts reported in an earlier blog (Beynon, 2025). Virtually all respondents (including some active climate negotiators) thought that even just the subset of 23 (Annex II) developed countries that have a formal obligation to provide climate finance are responsible for at least 60 percent of all GHGs since 1850, with most thinking more than 75 percent and many—particularly among those less familiar with climate—more than 90 percent.

GHG emissions: Key facts, challenges, and data sources

Sources of emissions

The United Nations Framework Convention on Climate Change (UNFCCC) focuses on controlling and tracking seven primary GHGs. These are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and a group of F-gases.[2]

Different GHGs have different effects on the Earth's warming (EPA, 2025) according to their ability to absorb energy ("radiative efficiency") and length of time spent in the atmosphere ("lifetime"). These factors are used to calculate the global warming potential (GWP) of each gas relative to the emission of 1 tonne of CO_2, usually measured over a 100-year time frame:[3]

- Carbon dioxide is the reference gas and has GWP of 1. It persists in the atmosphere for thousands of years.
- Methane has a 100-year GWP of 27–30. It lasts only about a decade, but traps far more heat than CO_2.
- Nitrous oxide has a 100-year GWP of 273 and remains in the atmosphere for over a century.
- F-gases have GWPs in the thousands to tens of thousands. Some (PFCs, SF_6, and NF_3) can persist for centuries to millennia.

About three-quarters of all emissions are in the form of CO_2 and about three-quarters come from the energy sector (Figure 1):[4]

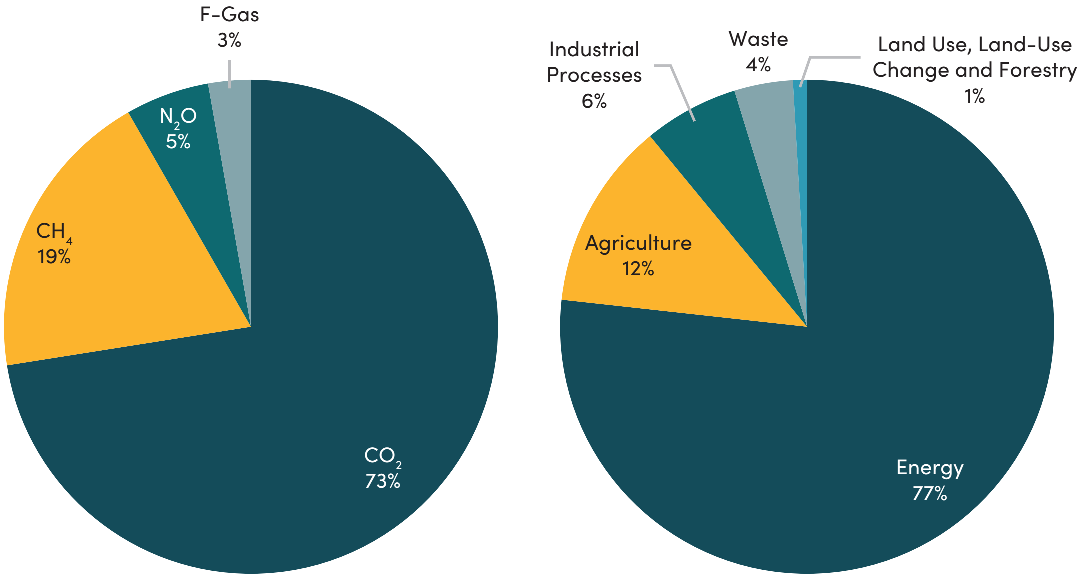
- Converted into CO_2 equivalents (CO_2e) using GWP, CO_2 makes up about 73 percent of annual global GHG emissions, with CH_4 19 percent, N_2O 5.5 percent, and F-gases 2.8 percent (Climate Watch, 2024 figures).
- Emissions are reported to the UNFCCC (as per their reporting requirements) across five sectors, with energy being the most significant (77 percent), followed by agriculture (12 percent), industrial processes (6.2 percent), waste (3.8 percent), and land use, land-use change, and forestry (0.9 percent) (Climate Watch, 2023 figures).

2 These fluorinated gases comprise hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) also count as GHGs but are controlled under the Montreal Protocol because of their ozone-depleting potential and are not included in GHG reporting to the UNFCCC.

3 GWP_{100} is the accounting metric adopted by the Intergovernmental Panel on Climate Change (IPCC) in inventory guidelines, although their Fifth Assessment Report (AR5) did not explicitly recommend its use. For a brief discussion, see Ritchie et al. (2020), which provides more detailed but accessible information on the global warming potential of different gases and their primary sources.

4 The energy sector includes emissions from electricity and heat (33.6 percent), transportation (14.3 percent), manufacturing and construction (12.2 percent), and buildings (6.3 percent). A more detailed breakdown using the Climate Watch platform and dataset is available here (Ge et al., 2024).

FIGURE 1. Composition of GHG gas emissions by gas (left) and sector (right)



Source: Climate Watch (2023 figures).

Carbon dioxide emissions are often disaggregated into fossil fuels (which account for about 84 percent of all CO_2 emissions), industry, and land use, land-use change, and forestry (LULUCF),[5] and are emitted through the following processes:

- *Oxidation* emissions produce the dominant share of anthropogenic CO_2 and come from the burning of fossil fuels (coal, oil, and natural gas) for energy, heat, and transport. Industrial processes also release CO_2 via oxidation of feedstocks (for example, in petroleum refining and iron/steel production), but not all of these processes require combustion.
- The *decomposition of carbonates* produces CO_2 emissions through industrial processes such as cement production and lime and glass production that are separate from the burning of fossil fuels.
- Emissions from *LULUCF* come from changes in carbon stored in vegetation and soils. Processes such as deforestation, forest degradation, drainage and burning of peatlands, conversion of grasslands, wetlands, or other ecosystems to cropland, and shifting cultivation and slash-and-burn practices, all emit CO_2. In addition, negative fluxes (carbon removal/sinks) are also included, for example reforestation, afforestation, and regrowth.

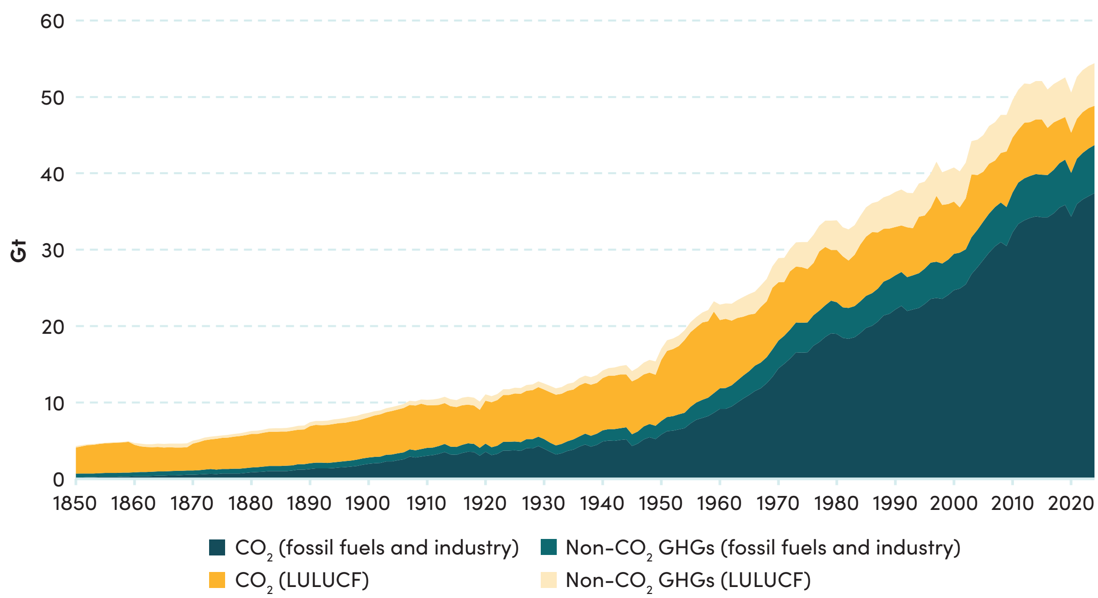
Methane is primarily emitted from agriculture, fossil fuel production (notably flaring), and the management of waste. Nitrous oxide emissions mostly come from agriculture through the

5 Coal, oil, and gas make up 37, 29, and 18 percent respectively of the 84 percent share from fossil fuels. Industry accounts for about 5 percent (with cement just over 3 percent and flaring and other processes about 1 percent each) and LULUCF about 10 percent (2024 figures from Our World in Data). Also see next footnote on discrepancy in LULUCF.

application of nitrogen fertilisers. F-gases primarily come from refrigeration, air-conditioning, and aerosol products.

The composition of emissions has changed significantly over time, with increases since 1850 driven almost entirely by fossil fuels and industry, although LULUCF remained the dominant source until the middle of the 20th century (Figure 2).[6]

FIGURE 2. The changing composition of CO_2 and GHG emissions, 1850–2024



Challenges involved in counting GHG emissions

Counting emissions accurately is not straightforward.

Carbon dioxide emissions are principally connected with the energy sector, which is a closely tracked commodity group, providing a wealth of data that can be used to estimate emissions. However, differences in collection methods and factors such as carbon content and fractions of oxidised carbon can lead to significant differences between datasets (Andrew, 2020). There is even more uncertainty around the decomposition of carbonates, around 80 percent of which come from cement manufacturing and specifically the production of clinker that is used in the production of cement.

Estimates of LULUCF emissions are especially uncertain for a number of structural and conceptual reasons, including large heterogeneity in fluxes across time and space (driven by complex biological, geochemical, and physical processes combined with variable anthropogenic

6 These figures are significantly higher than the source data in Figure 1 (from Climate Watch) due to differences in the way LULUCF emissions are measured. For LULUCF, sources vary in using data based on national emissions inventories (e.g., Climate Watch) to top-down bookkeeping models per the Global Carbon Budget (and therefore OWID). See also next section.

and natural disturbances), the inability to continuously observe fluxes over time and over large areas, and differences in definitions and accounting methods across countries and studies (McGlynn et al., 2022). Emissions from flaring are also difficult to measure, as are the measurement and attribution of emissions from international transport, which are excluded from national totals and reported separately to the UNFCCC.

Several papers have considered some of these challenges and looked at differences arising from different datasets. Andrew (2020) focuses on CO_2 emissions, noting that while all datasets include emissions from fossil fuels, fewer include either land-use change or carbonates. He concludes that much of the difference between different estimates of CO_2 emissions results from these differences in what he calls "system boundaries."

Minx et al. (2021) look more broadly at all GHGs, emphasising the challenges in accurately tracking the recent GHG performance of countries and sectors. They note that while there are a growing number of global emissions inventories, only a few of them provide a wide coverage of gases, sectors, activities, and countries or regions that are sufficiently up to date to comprehensively track progress and thereby aid discussions in science and policy. Uncertainty about the scale of emissions is greater for LULUCF and for non-CO_2 gases. Data on older historical emissions are inevitably even weaker.

An analysis of uncertainty in GHG emissions data is set out in chapter 2 of Working Group III's contribution to the IPCC Sixth Assessment Report (IPCC, 2022). It concludes that estimates of global total GHG emissions have an uncertainty of ±11 percent, with relatively low values for CO_2 from fossil fuels and industry (±8 percent), intermediate values for CH_4 and F-gases (±30 percent), and higher values for N_2O (±60 percent) and CO_2-LULUCF (±70 percent).

And in the most recent paper, Lamb et al. (2026) examine differences in global and national GHG emissions estimates, focusing on the role of varying system boundaries and conceptual approaches in driving these variations. They find that estimates differ significantly due to differences in their coverage of gases, sectors, and countries and different approaches to defining "anthropogenic" emissions and removals in the LULUCF sector. This partly reflects differences in objectives, with three different assessment conventions that report or use emissions data: those focused on interpreting national progress, policies, and pledges under the Paris Agreement; those consistent with integrated assessment modelling (IAM) benchmarks of emissions under different warming scenarios; and those consistent with climate forcing assessments. They find that global emissions amount to 44.4, 54.5, and 56.4 $GtCO_2e$ per year on average over the period 2014–2023 for these three conventions, respectively.

Key data sources

The IPCC (2022) notes that a growing number of global GHG emissions inventories have become available since its fifth Assessment Report, but that only a few are comprehensive in their coverage of sectors, countries, and gases. It specifically mentions EDGAR (Emissions Database for Global

Atmospheric Research), PRIMAP (Potsdam Real-time Integrated Model for probabilistic Assessment of emissions Paths), CAIT (Climate Analysis Indicators Tool), and CEDS (Community Emissions Data System for Historical Emissions), though notes that none of these inventories cover CO_2 LULUCF emissions (though some now do), while CEDS excludes F-gases.[7]

The IPCC uses EDGAR for a consistent assessment of GHG emissions trends and drivers, saying that "EDGAR is chosen because it provides the most comprehensive global dataset in its coverage of sources, sectors and gases." It supplements this with data from the Global Carbon Project (GCP) to capture net CO_2 emissions from LULUCF (using an average of the GCP's three "bookkeeping" models of land-use emissions). But this still does not capture non-CO_2 gases from the LULUCF sector, and EDGAR itself only has data since 1970.

In our comparative analysis of GHG emissions data, we aim to consider emissions from all GHG gases as well as just CO_2 and to consider estimates both with and without emissions from the LULUCF sector, in line with UNFCCC's reporting requirements. We also seek to assess historical emissions from all countries going back as far as 1850, the date generally regarded as representing the start of the industrial era from which anthropogenic emissions begin to rise.[8]

We therefore draw on the following sources and datasets (not all of these go back as far as 1850, but the inclusion of others allows a broader assessment of the comparability of different datasets over different time periods):

- The GCP now provides data on CO_2 emissions from all sources for the period 1750–2024, with three alternative bookkeeping models used to estimate LULUCF emissions. But it only focuses on CO_2 and excludes all other GHGs.
- PRIMAP, produced by the Potsdam Institute for Climate Impact Research (PIK), provides a comprehensive time series of GHG emissions for all countries from 1750–2024, combining data submitted to the UNFCCC with other sources to fill gaps. LULUCF data are available, but authors emphasise they should be used with care as they are constructed from different sources using different methodologies and are not harmonised.
- EDGAR, produced by the European Commission's Joint Research Centre (JRC), provides country-level time series of GHG emissions covering fossil fuel combustion, industrial processes, agriculture, and waste from 1970–2024, with LULUCF estimates also available from 1990–2024 following the latest update released in September 2025.
- Climate Watch (previously CAIT), run by the World Resources Institute, covers all sectors and gases from 1990–2023, drawing on a variety of sources (but not official inventories

7 See section 2.2 of chapter 2, here (IPCC, 2022). This provides the full references, though some have since been updated.
8 There is some debate among historians about precisely when the Industrial Revolution started, but it is from about 1850 that there begin to be noticeable increases in the volume of GHG emissions from industrial activity, and this is the date from which data begin to be more comprehensive. The IPCC itself uses 1850 as the starting year when examining historical emissions (IPCC, 2022, section 2.2.3).

reported to the UNFCCC) to maximise comparability across countries. It also functions as an online platform providing data visualisations and resources that include some (but not all) of the PIK and GCP data, as well as the (incomplete) data reported by countries to the UNFCCC.

- Our World in Data (OWID), another well-known and widely used platform, also provides online visualisation tools to explore trends and patterns with some disaggregation by gas, sector, and country. Their emissions data draws on Jones et al. (2025), which uses the GCP for CO_2 emissions and PRIMAP for other GHGs (just CH_4 and N_2O).
- Jones et al./GMST (2025) is also included for the data series on contributions to increases in global mean surface temperature (GMST). This is relevant because the global warming impact of early emissions of GHGs with a relatively short lifetime (notably nitrous oxide and methane) is effectively zero,[9] although F-gases are excluded.

These sources all draw largely on the same or similar body of primary data, and indeed each other, but combine and extrapolate them in different ways when filling gaps and constructing time series. A more detailed summary of their main features is provided in Annex A.

The World Bank, a major provider of development data, also includes indicators on GHG emissions. But these are sourced directly from OWID (for its CO_2 and GHG emissions dataset) and EDGAR (in its World Development Indicators, only from 1960) and are not repeated in our analysis here.

A comparative analysis of historical emissions from different datasets

This section builds on preliminary analysis published during COP30 (Beynon, 2025). It includes recent updates to the major datasets (most of which now capture 2024 emissions data) and more comprehensive coverage of alternative country groups and time periods.

We first briefly describe how we constructed the spreadsheet underpinning this analysis. Next, we present key results for different categories of emissions, time periods, and country groups, using all applicable data sources. The subsequent section then addresses a number of issues that have been raised in the context of assigning responsibility for climate change, notably regarding colonial, consumption, and per capita emissions.

9 It is for this reason that OWID do not include data on cumulative GHG emissions in their CO_2 and GHG Emissions Data Explorer (which allows the user to display emissions in per capita, per country, and cumulative terms for CO_2, but only in per capita and per country terms for all GHGs), but instead recommend using the "Contribution to GMST rise" data series (Pablo Rosado, pers.com, 18 Oct 2024). Jones et al. (2025) uses the GWP* (rather than GWP100) to better represent the actual warming impact of short-lived pollutants like methane.

Methods

Data were extracted from the source datasets identified above, standardised where necessary into common units (million tonnes of CO_2 equivalent, or $MtCO_2e$), and stacked into a single table. This allows cumulative totals for each of four measures of territorial emissions (CO_2 or all GHGs, with or without LULUCF) to be calculated for each individual country for any given period of time according to start and end dates specified by the user.[10] Figures for international transport are also included wherever these are captured by each dataset, although to be consistent, we calculate shares of different country groups on the basis of global totals *excluding* international transport.

Individual country totals (and percentage shares) are then aggregated into a wide range of country groupings as follows:

- *Institutional group*: Whether a country is categorised as Annex I ("developed"), Annex II (a subset of 23 Annex I countries that have a formal obligation to provide climate finance), or non-Annex I ("developing") according to UNFCCC classifications.[11] We focus on these because of their prominence in climate negotiations, although it is notable that the Paris Agreement itself refers to "developed" and "developing" countries without explicit reference to the Annexes. In addition, figures are calculated for the OECD, EU, BRICS, G7, and G20 groups of countries.[12]
- *Income group*: Whether a country is classified as high income (HIC), upper middle income (UMIC), lower middle income (LMIC), or low income (LIC), using the World Bank's latest categorisation based on 2024 calendar year data. Note that there will be some differences since our earlier work on fair shares and climate and development (which used 2022 income categories), as some countries have graduated up or moved down to a different income group.[13]
- *Development group*: Whether a country is categorised as a least developed country (LDC), landlocked least developed country (LLDC), or small island developing state (SIDS). A further category capturing the 100+ countries that are either one or more of the LICs, LMICs, SIDS or

10 An option to adjust for colonial legacy is also included (see later discussion).

11 The original Annex I list of countries in the 1992 Convention is available here and Annex II here. Türkiye was originally categorised as Annex II but was removed from Annex II in 2002; the Czech Republic, Croatia, Liechtenstein, Monaco, Slovakia, and Slovenia were added to Annex I in 1998, Malta in 2010, and Cyprus in 2013. There are now 42 Annex I countries. Colenbrander et al. (2023), especially chapter 2, has a useful summary of the Annex classifications and the evolving understanding of what constitutes "developed" and "developing." Given the inclusion of the European Economic Community in the original classification (with each of the 12 EEC members already being one of the 23 Annex II countries), an "Annex II+EU" category is also included in our analysis.

12 The BRICS group shown here is Brazil, Russia, India, China, and South Africa. The G20 group only includes the 19 individual countries and excludes other members of the EU27 and African Union.

13 Most notably Russia and Bulgaria, which graduated from UMIC to HIC in 2023, as did Costa Rica in 2024. A number of other countries moved between the LIC and MIC groups. Ethiopia, though labelled as being "currently in a temporary status of unclassification for FY26" on the website, is assigned a LIC classification in line with the WB's downloadable spreadsheet on historical classifications.

LDCs (as used in our climate finance "fair shares" analysis but updated to reflect latest classifications) is also applied.

- *Regional group*: This applies the World Bank's latest regional categorisations of Europe and Central Asia (ECA), North America (N.Am), Latin America and the Caribbean (LAC), East Asia and the Pacific (EAP), South Asia (SA), Middle East and North Africa (MENA), and Sub-Saharan Africa (SSA), noting that these have recently changed so are not directly comparable with earlier "fair shares" analysis.[14]

Our primary interest is in shares coming from developed and developing categories, for which we focus on the UNFCCC's Annex I, Annex II, and non-Annex I country groups, although the shares of high-income compared to low- and middle-income countries are also pertinent.

Results

We start initially with cumulative emissions since 1850, the most relevant date for assessing historical responsibility for the rise in anthropogenic emissions, before considering the more recent period since 1990. The charts and discussion focus on the Annex I and Annex II categories, but full details for all country groups are set out in tables in Annex C.

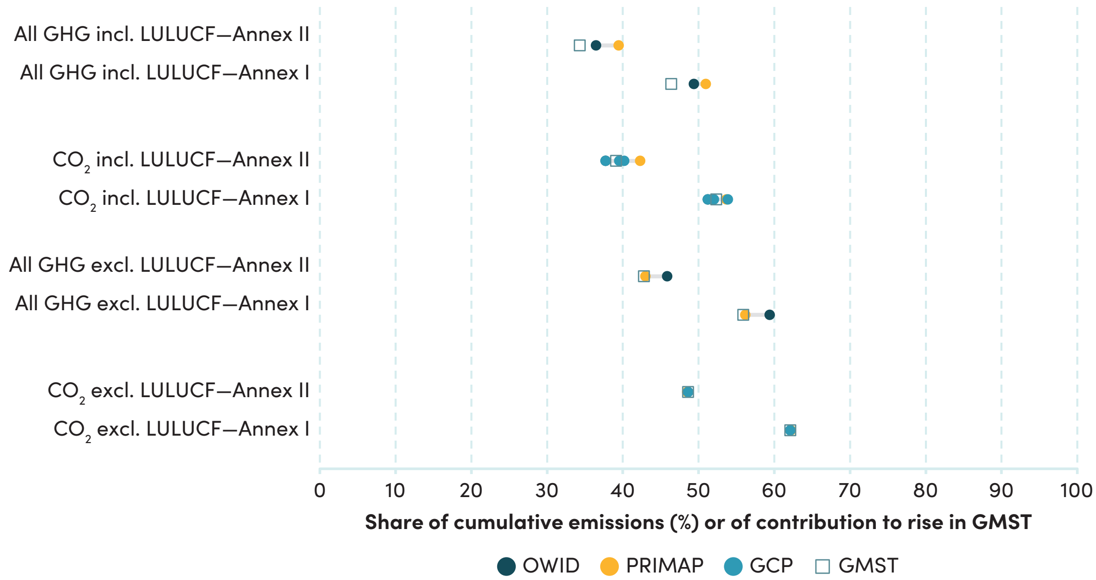
1850–2024 analysis

We first find (Annex C) that different datasets can yield significantly different estimates of total cumulative emissions, with aggregate figures varying by 14 percent for all GHGs including LULUCF, 24 percent for all GHGs excluding LULUCF, and nearly 30 percent for CO_2 including LULUCF (though only 4 percent for CO_2 excluding LULUCF). But different datasets are much more consistent in their estimates of developed and developing country *shares* of those emissions.

Results from all available datasets for the period 1850–2024 for our four emissions measures are summarised for Annex I and II countries in Figure 3 below.

14 Afghanistan and Pakistan were moved from the South Asia region to the Middle East & North Africa region (renamed Middle East, North Africa, Afghanistan and Pakistan) in FY26 ending July 2026. See here.

FIGURE 3. Shares of emissions, and of contributions to increased GMST, 1850–2024



We find that the current group of mandated climate finance providers (Annex II countries)[15] is responsible for 36–39 percent of cumulative historical GHG emissions from 1850–2024, according to the two sources that cover this (PRIMAP and OWID). The data of Jones et al. (2025) on contributions to rises in GMST, which take account of the short-lived nature of some GHGs such as methane and are arguably a better reflection of contributions to global warming, suggest Annex II shares are lower at 34 percent.

Expanding our definition of developed countries to all Annex I countries (which include most of the rest of Europe, Türkiye, and Russia) significantly increases their share of all GHGs to about a half (49–51 percent), although their share of contributions to rises in GMST is still less than half at only 46 percent.

Limiting the measure of emissions to just CO_2 (which allows us to include data from the GCP) results in an Annex II share since 1850 of 38–42 percent, and an Annex I share of 51–54 percent (in this scenario shares of contributions to global warming are the same because the effects of CO_2 persist for thousands of years). But even if the exclusion of other GHGs could be justified (and we would argue it cannot), these figures are still well short of widespread perceptions.

Further restricting the measure to emissions from just fossil fuels and industry (excluding LULUCF, around which there is greater uncertainty) increases developed country shares by 5–10 percentage points. The most extreme scenario (the highest estimate for CO_2 emissions excluding LULUCF from

15 These are the countries with a formal obligation to provide climate finance, though many others also do so on a voluntary basis.

all Annex I countries) yields a developed country share of 62 percent, closer to but still short of most perceptions.

But while developing country (non-Annex I) shares may therefore be higher than generally perceived, responsibility is concentrated amongst relatively few countries. For example, the nine non-Annex I members of the G20[16] alone account for 30 percent of all GHG emissions including LULUCF (cf. 50 percent for all non-Annex I countries). LICs account for just 2–3 percent, and the 100+ countries that are either LICs, LMICs, SIDS or LDCs account for just 14–16 percent (see Tables in Annex C).

1990–2024 analysis

We then consider the implications of using a more recent cut-off date from which emissions are counted, although this remains the subject of much debate. We choose 1990 because this allows us to incorporate both the EDGAR and Climate Watch datasets. Most analysts looking at climate finance fair shares have also focused on the period since 1990, as this was the year when the first IPCC report was published, providing a clear scientific consensus that could be used politically to justify domestic action, although an 1850 cut-off date provides the most comprehensive measure of historical responsibility.[17] Results for Annex I and II countries are summarised in Figure 4 below (full details in Annex C).

We again find significant differences in estimates of total cumulative emissions (varying by around 20 percent for both GHG series, over 30 percent for CO_2 including LULUCF and 10 percent for CO_2 excluding LULUCF), but much smaller differences in developed and developing country shares.

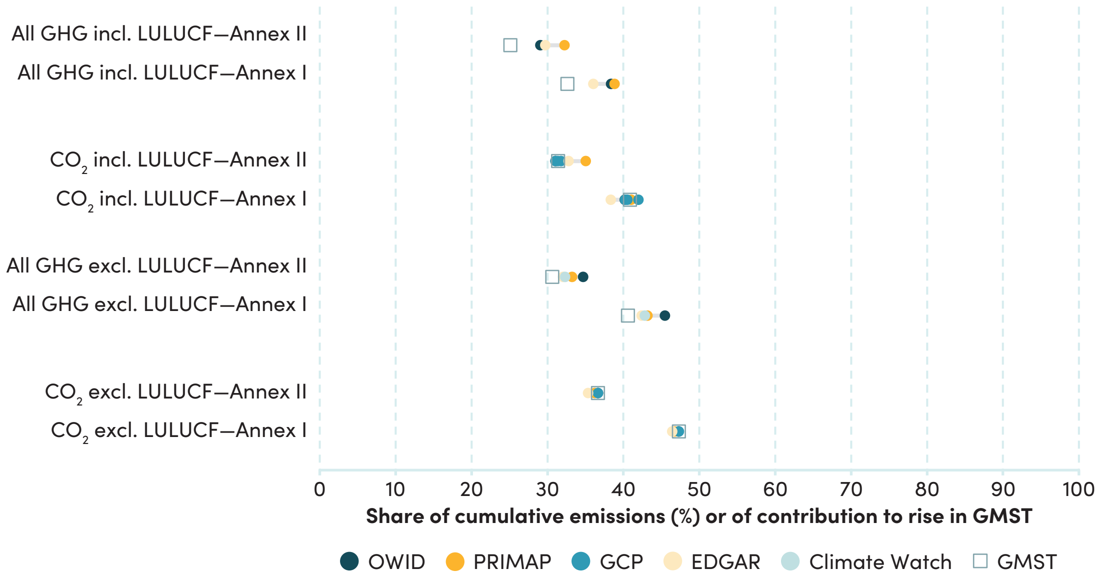
Developed country shares are significantly lower than for the period since 1850 for all four measures of emissions. For example, the Annex II share of all GHG emissions since 1990 ranges from 29–32 percent, while their share of contributions to rises in GMST is just 25 percent. Figures for Annex I countries are 36–39 percent and 33 percent respectively. The highest estimate (for CO_2 emissions excluding LULUCF from all Annex I countries) yields a developed country share of 47 percent, down from 62 percent when using 1850 as the starting point. Developing country shares are again heavily concentrated, with the nine non-Annex I members of the G20 accounting for 40 percent all GHG emissions including LULUCF (compared with just over 60 percent for all non-Annex I countries).

16 Argentina, Brazil, China, India, Indonesia, Mexico, Saudi Arabia, South Africa, South Korea.

17 See Beynon (2023a), which reviews a number of climate finance fair shares models, almost all of which used 1990 as the cut-off date. This debate remains highly charged, with some invoking *mens rea* legal arguments that *culpable* responsibility requires knowledge of the impact of one's actions. Our initial "fair shares" analysis (Beynon, 2023a) used 1979 in its baseline scenario, as this was when (based on analysis of text in international discussions at the UN General Assembly) there was a clear step-change in climate awareness. Applying a 1900 cut-off date increased the Annex II "fair" climate finance share from 77 percent (with a 1979 cut-off) to 83 percent (and almost the same with an 1850 cut-off date), while a 1990 cut-off date reduced it to 76 percent (these results were for CO_2 excluding LULUCF. Results using all GHGs are about four percentage points lower in each case).

LICs account for just 2–4 percent, with all LICs, LMICs, SIDS and LDCs collectively accounting for just 15–19 percent (see Tables in Annex C).

FIGURE 4. Shares of emissions, and of contributions to increased GMST, 1990–2024



Note: Climate Watch data is only available up to 2023.

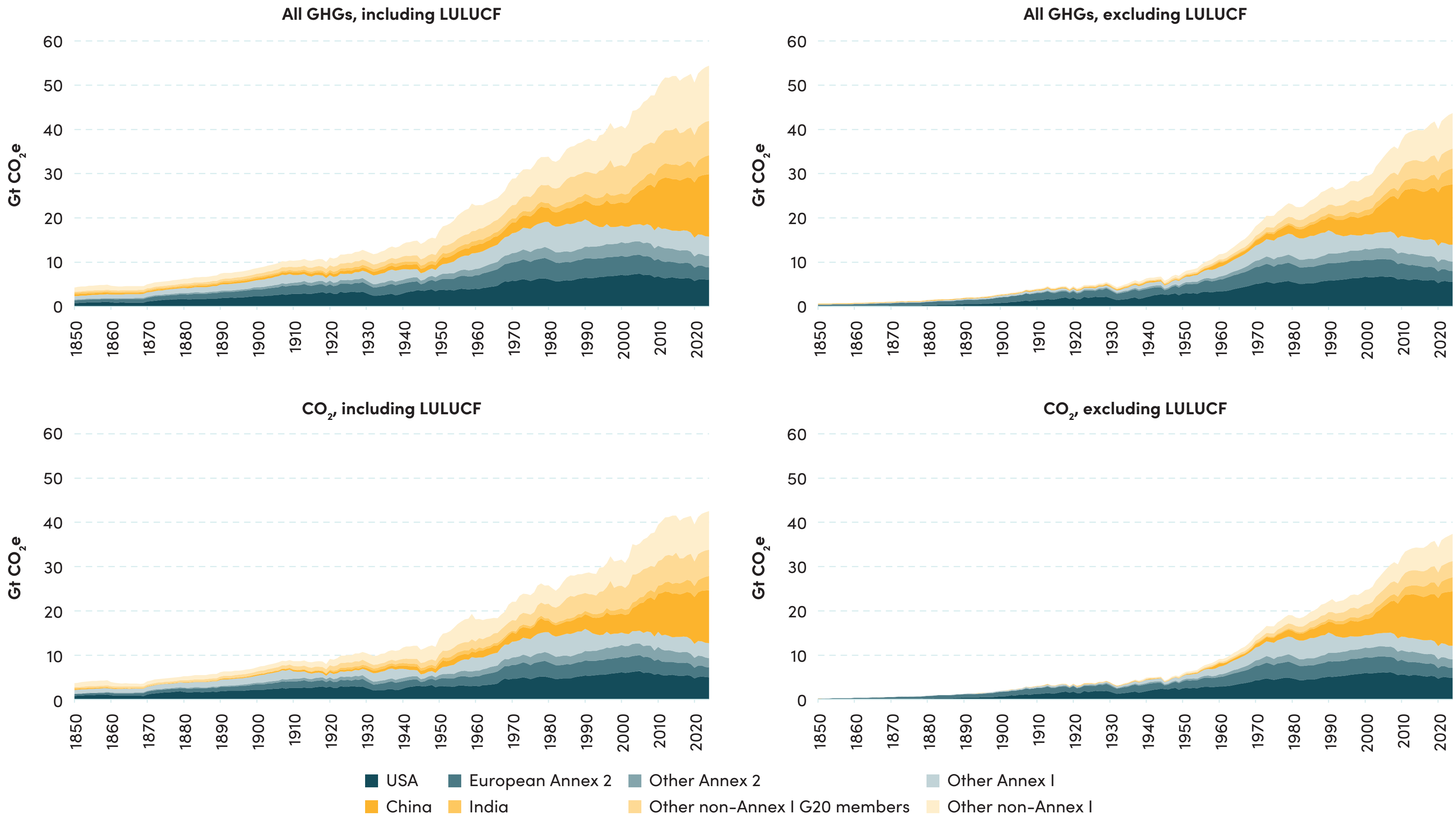
The main reason for these (even) lower figures is that around 40–45 percent of GHG emissions have been produced since 1990,[18] with emissions falling in most advanced countries while rising rapidly in many emerging economies, a reflection of the extraordinary economic progress that many have made.

The following charts illustrate these points.

Figure 5 illustrates the extraordinary growth in GHG emissions over time, particularly since the mid-1900s, using all four measures of emissions. But it also clearly shows that emissions have been falling in developed countries since around 2005 for CO_2 and around 1990 for all GHGs, as well as the explosive growth in developing country emissions, particularly since 1990. China accounts for much of this, and far more than India or the other non-Annex I G20 members, although total emissions from other developing countries also rise very substantially.

18 Conversely, 50–55 percent of all emissions occurred *prior* to 1990, which is why 1850 is the more appropriate cut-off date for assessing historical responsibility.

FIGURE 5. Total emissions, 1850–2024



Notes: Non-annex I G20 members are Argentina, Brazil, China, India, Indonesia, Mexico, Saudi Arabia, South Africa, and South Korea.

Source: Our World in Data (we just use the one data source for ease of presentation).

FIGURE 6. The changing pattern of emissions shares since 1850 (with different end years to 2024)

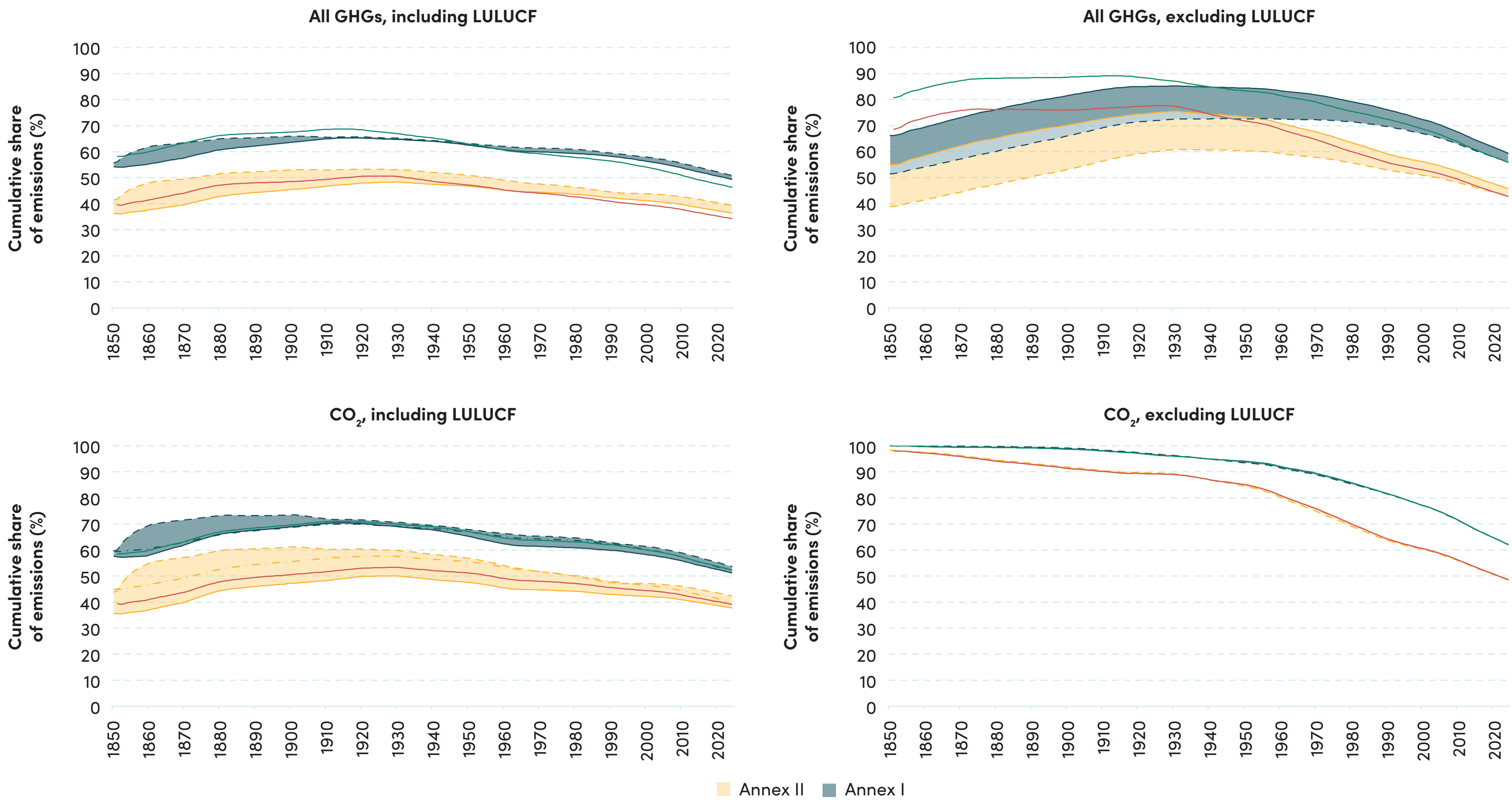


Figure 6 illustrates how developed country emissions shares have changed over time, using 1850 as the starting year and plotting the evolution of cumulative shares with each additional year's emissions up to 2024 (such that figures for 1990, for example, report the shares of cumulative emissions for the years 1850–1990).

The top two charts cover all GHGs, the bottom two just CO_2. The left-hand side includes LULUCF, the right-hand side excludes LULUCF. In each chart, Annex I shares are shown in blue, with the (lower) Annex II shares in orange. Each "fan" displays the maximum and minimum shares from the various datasets, with the dotted lines representing data series that lie between these extremes. The solid lines (blue for Annex I, red for Annex II) report each group's share of contributions to increases in GMST. In all four charts, the figures shown for the final year 2024 correspond to those shown in Figure 3.

The four charts tell rather different stories. The two GHG charts show developed country shares steadily rising up to the early 1900s, peaking at around 53 percent for Annex II and 66 percent for Annex I countries (including LULUCF), and (a little later) at 60–75 and 70–85 percent respectively excluding LULUCF, before falling steadily thereafter.[19] On the surface there is less variation between the sources when *including* LULUCF, which is surprising given that LULUCF emissions data are generally held to be much more uncertain. However, the explanation is that this masks disagreements between the sources about the volume of emissions from the LULUCF and non-LULUCF components that tend to counteract each other.[20]

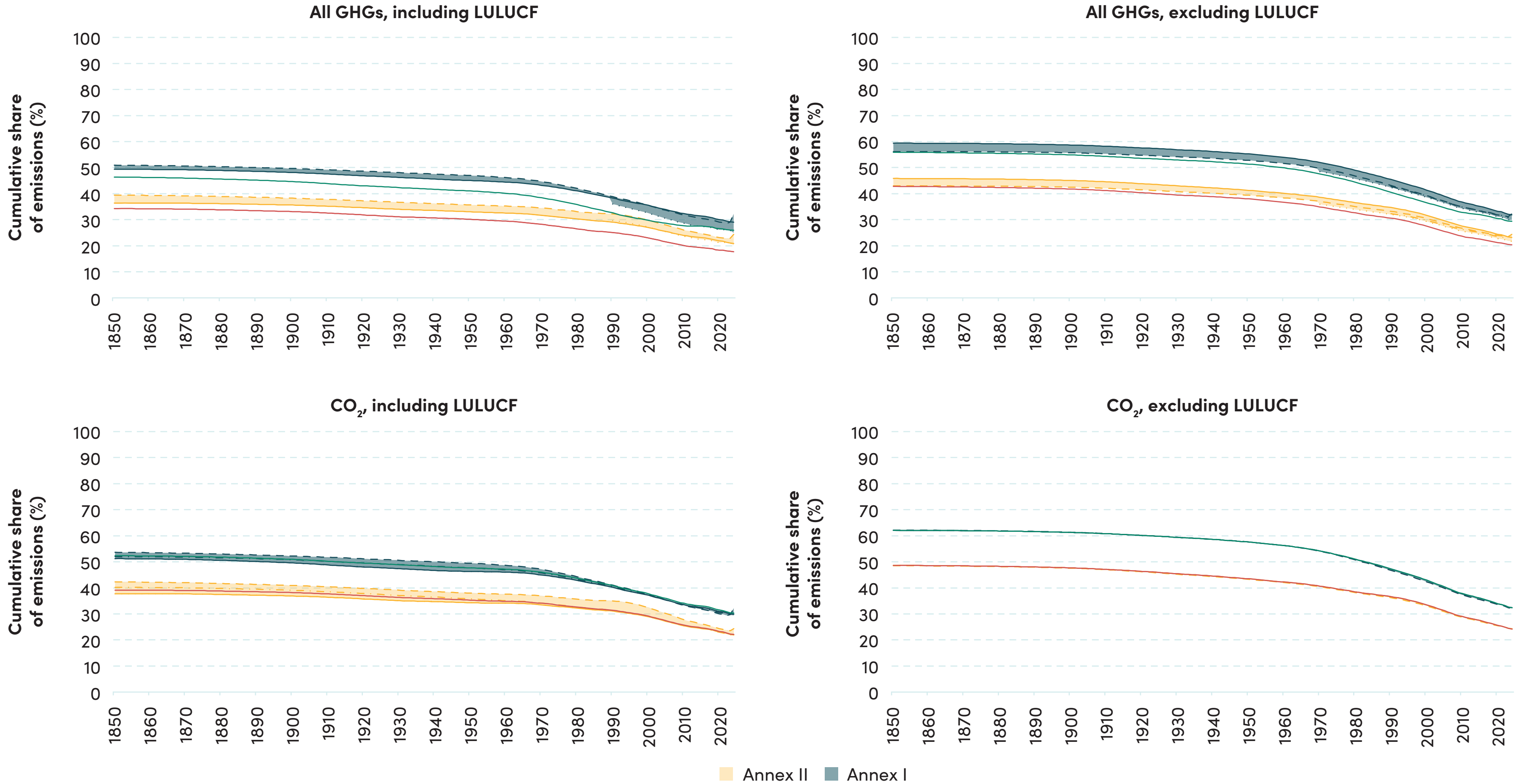
The two CO_2 charts show developed country shares starting much higher (close to 100 percent excluding LULUCF) but falling with each passing year: reasonably steadily for the data including LULUCF, but much more steeply from the 1960s for the data excluding LULUCF (reflecting the increasingly rapid rise in developing country fossil fuel CO_2 emissions). As expected, there is much greater variation in the series including LULUCF, especially in the earlier years when LULUCF represented a much greater share of total emissions.

Figure 7, in contrast, shows how cumulative emissions have changed as we alter the starting year. Figures for 1990, for example, report the shares of cumulative emissions 1990–2024 (and thus correspond with those in Figure 4, while those for 1850 correspond with those set out in Figure 3). Figures for 2024 represent developed countries' current share of emissions (with the OWID data matching the 2024 figures in Figure 5).

19 The finding that the GMST shares for all GHGs excluding LULUCF (top right) lie some way *above* the range for GHG shares in the early years is slightly unexpected but may reflect differences in fuel mix and conversion methods for CO_2 equivalence.

20 This is especially true in the earlier years. To take Annex I emissions of all GHGs from 1850 to 1870 as an example, PRIMAP estimates non-LULUCF emissions at 21.87 Gt, while OWID estimates them at 13.43 Gt (8.44 Gt *lower* than PRIMAP). For emissions from LULUCF, PRIMAP estimates emissions to be 33.15 Gt, while OWID estimates them at 43.72 Gt (10.57 Gt *higher* than PRIMAP).

FIGURE 7. The changing patterns of emissions shares to 2024 (with different start years from 1850)



All four charts clearly show that the shares of emissions (and contribution to increases in GMST) from developed countries are lower than commonly assumed even with an 1850 starting point (as noted previously). They also show that these shares decline only slightly as we consider ever more recent starting points, at least up until the 1950s, suggesting that choice of starting point matters little prior to this date. However, the curves bend more steeply downwards after the 1970s for Annex I countries, and after the 1990s for Annex II countries (with some variation depending on the measure of emissions, but not much).[21] This reflects the much more rapid growth in developing country emissions over the past 50 years, with results much more sensitive to the specific start date if attention focuses on the more recent past.

Additional issues: Colonial, consumption, and per capita emissions

The analysis to date has focused on aggregate territorial emissions produced by each country in the world. But there are three other factors that are often raised when debating country contributions to GHG emissions and responsibility for climate change. These concern colonial, consumption, and per capita emissions.

Colonial emissions

Colonialism has long been a highly charged topic, but the notion that former colonial powers have developed and prospered in part through the extraction of resources from their colonies, and that those colonies are not entirely responsible for their emissions while under colonial occupation, is not an unreasonable one. There is, therefore, a case for attributing at least some of those emissions to their colonial power. Earlier Carbon Brief analysis (Evans and Viisainen, 2023) found that attributing all emissions from colonies to their respective colonial power makes a significant difference to the emissions of some individual countries, notably the UK (whose cumulative emissions since 1850 increase by 70 percent) and the Netherlands (up 180 percent),[22] although their analysis focuses just on CO_2 emissions including LULUCF.

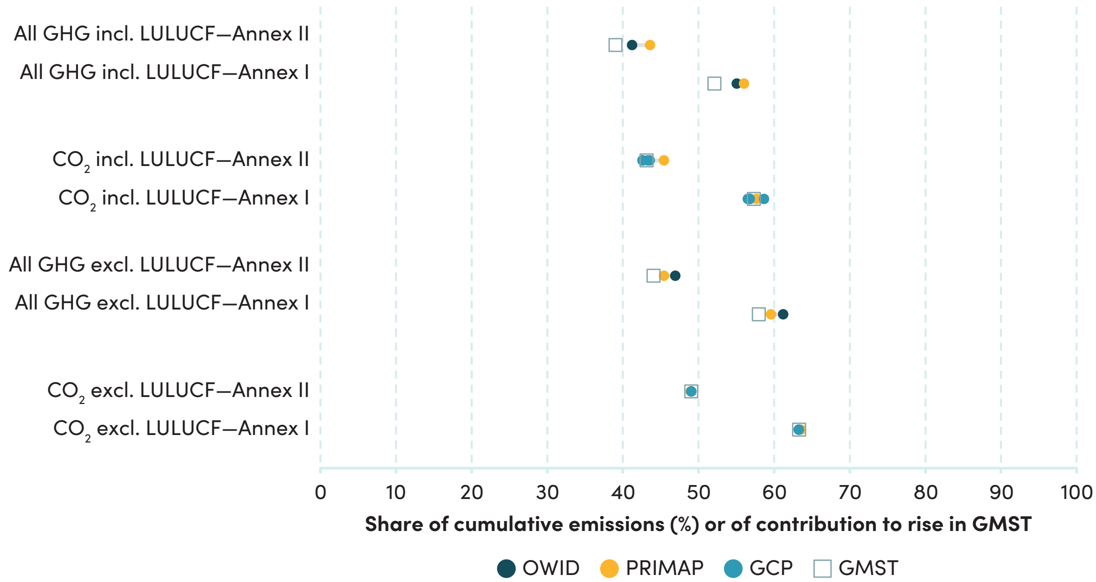
To assess this impact on developed and developing country emissions more fully, we apply Carbon Brief's data on the patterns of colonial occupation to each of our emissions datasets (Figure 8). We find that Annex II shares of all GHG emissions since 1850 rise from 36–39 percent without colonial emissions to 41–44 percent once colonial emissions are added. Figures for all Annex I countries rise

21 It is worth noting that the slight uptick visible in 2024 in some charts is because data gaps for this most recent year are particularly significant in developing countries.

22 Emissions from Russia and France also rise substantially in absolute terms, although are not as large in percentage terms. Other large percentage increases in emissions are seen in Portugal (up 234 percent), Austria, and Hungary (both up at least 70 percent). Of former colonies, notable reductions are seen in India (down 15 percent) and Indonesia (down 24 percent).

from 49–51 percent to 55–56 percent. Figures for the most extreme scenario (CO_2 excluding LULUCF in Annex I countries) are little changed, rising from 62 to 63 percent.

FIGURE 8. Shares of emissions, and of contributions to increased GMST, 1850–2024, adjusted for colonial legacy



Unsurprisingly, adjusting for colonial emissions makes virtually no difference at all to our results when limiting analysis to the period since 1990 (not presented here, for brevity).

However, as Carbon Brief also acknowledges, it would be equally unreasonable to assign *full* responsibility to the colonial powers, and the true share of responsibility for current warming lies somewhere between these two extremes. In short, allowing for colonial legacies makes relatively little difference to the overall picture.

Consumption emissions

The analysis to date has focused on territorial emissions (emissions produced within a country's geographical borders), in line with UNFCCC reporting requirements, although some countries have been able to reduce such emissions at home by importing high-carbon goods from overseas. While exporting countries benefit from the jobs and economic activity associated with their production, some have argued therefore that consumption-based accounts give a fairer picture of responsibility for emissions.

Another Carbon Brief analysis (Evans, 2021) has also considered this question, noting first the practical challenges to gathering such accounts, which rely on detailed trade tables. As a consequence, data are generally only available for the years since 1990 and are limited to CO_2 emissions from fossil fuels and industry. With those caveats in mind, they find that using consumption-based emissions actually makes little difference: the top 19 countries according to their cumulative consumption emissions are the same as the top 19 on a territorial basis, none of the top 10 shift position in the rankings, and changes to the shares of individual countries are pretty small.[23] In total this may add at most 2–3 percentage points to developed country shares.[24] Moreover, they note that trade patterns have changed significantly over time, with the UK, Germany, and the US in particular previously playing the role of "workshop of the world," exporting large volumes of energy- and carbon-intensive goods well into the 20th century.[25] It is therefore not clear that the share of developed country cumulative emissions would be very much higher even if data did exist going back to 1850.

Per capita emissions

Regardless of the data on aggregate emissions, questions of equity and justice feature prominently in UNFCCC discussions, with developing countries pointing out that developed countries have largely developed on the back of fossil fuels and that their per capita emissions remain significantly higher than for most developing countries (see Figure 9).[26] So while developed (Annex I) countries may account for "only" 49–51 percent of cumulative GHG emissions since 1850, that is still significantly larger than their 17 percent share of world population in 2024.[27]

23 They find that the US and Japan each gain 0.3 percentage points of the global cumulative total, while Germany and the UK add 0.2 points each. China's share drops by 1.1 points, and Russia's by 0.5.

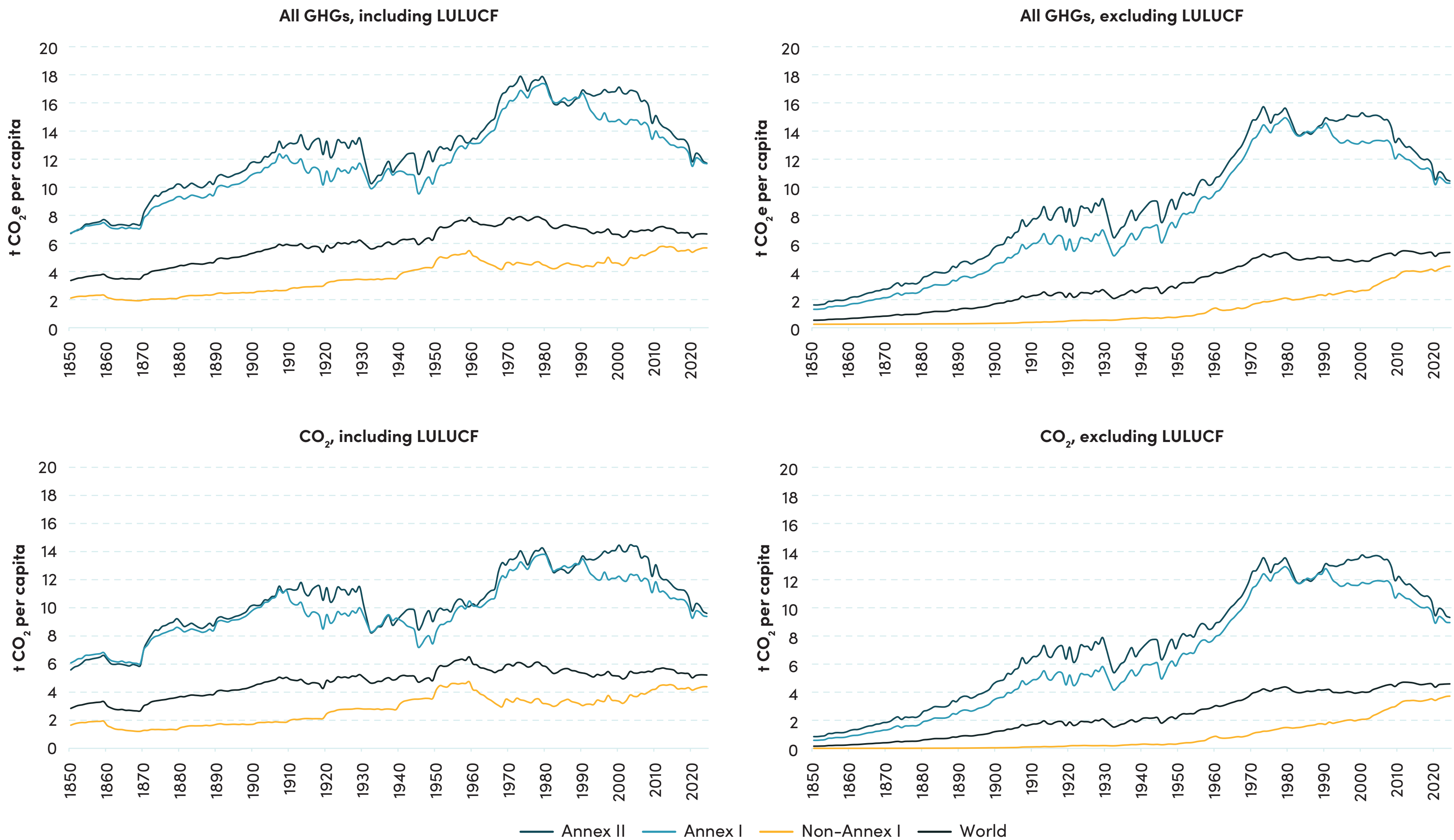
24 Hickel (2020), however, suggests that cumulative consumption CO_2 emissions excluding LULUCF in the US, EU-28 (including UK) and Japan are about 6 percent higher than territorial emissions for the period 1970–2015.

25 For example, exported goods accounted for 19 percent of Great Britain's energy consumption in 1890, and 16 percent of Germany's in 1913, a similar level to China's today (Kander et al., 2017). And while much of this was to other developed countries (though Kander et al. note that India was also then a significant trading partner of Great Britain), international trade represented a much smaller share of the global economy for most of the period prior to the rapid rise in globalisation from the 1970s (Esteban et al., 2018).

26 These figures are the average for each group and mask significant variation between countries *within* each group.

27 The picture with respect to *individual* emissions is even starker: OXFAM reports that the world's richest 1 percent (not all of whom live in rich countries) accounted for 17 percent of total CO_2 emissions on a consumption basis in 2023 (75 tCO_2/hd), while the richest 10 percent accounted for 48 percent (22 tCO_2/hd) of total emissions. The poorest 50 percent accounted for 8.4 percent (0.8 tCO_2/hd), and the poorest 10 percent accounted for just 0.4 percent of total emissions (0.2 tCO_2/hd) (Dabi et al., 2025, Table 1).

FIGURE 9. Annual per capita GHG emissions, 1850–2024



Source: Our World in Data (we just use the one data source for ease of presentation).

Many argue that equity requires equalising per capita emissions, particularly in the context of emissions reduction pathways and fair shares of the remaining carbon budget (which may justify financial transfers from *current* high-to-low per capita emitters during a pathway to net zero).[28] But some have specifically proposed *cumulative* per capita emissions should be the basis for assessing historical responsibility for climate change in the context of climate finance obligations. That is much more problematic.[29] As Professor Pierre Friedlingstein, chair in mathematical modelling of climate systems at the University of Exeter and lead author of the Global Carbon Budget, notes: "What matters for the atmosphere and the climate is cumulative CO_2 emissions. While cumulative per-capita emissions are interesting, they shouldn't be interpreted as country shares of responsibility because they're not directly relevant to the climate. You would have to multiply it by the country's population to make that link to warming" (quoted in Carbon Brief). And from a climate finance perspective, while large countries are likely to have higher aggregate emissions even if their per capita emissions are lower, they also have larger populations over which to spread any financial responsibility that might arise. Focusing on per capita emissions therefore produces flawed results. For example, if two countries A and B have equal (both cumulative and current) per capita emissions, but total populations of one million and one billion respectively, then judging them to be equally responsible based on their per capita emissions means that people in A are paying 1000 times more per head than people in B.

Nevertheless, given the widespread attention to the issue, it remains an interesting question to explore. The rest of this section does just that. The first point to note is that there are three different ways of estimating cumulative emissions per capita:

a) Aggregating per capita emissions in each year of the period under consideration for each country. This effectively gives equal weight to the per capita emissions of both past and present populations, regardless of their size (akin to an *unweighted* average).
b) Aggregating total emissions for the period under consideration for each country and dividing by each country's current population. This effectively places the responsibility of all historical emissions on each country's current population.
c) Aggregating total emissions for the period under consideration for each country and dividing by the sum of that country's population in each year of the same time period. This differs from "a" above in that it is more akin to a *weighted* average, with more weight given to years when each country's population is larger.

28 Beynon (2023b) showed that *current* inequalities in per capita CO_2 emissions represent an *annual* transfer from LICs and LMICs to UMICs and HICs of somewhere between $500 billion and $3.7 trillion depending on the price of carbon (though this masks the fact that there will be some HICs/UMICs with current per capita emissions below the global average and some LICs/LMICs above the global average. A better presentation would instead just distinguish between countries above and below the global average).

29 ODI, for example, used cumulative territorial CO_2 emissions per capita since 1990 as a proxy for a country's responsibility for our changed climate in their work to identify new climate finance contributors (Colenbrander et al., 2023), although their use of *both* historical emissions and income in *per capita* terms effectively ignores population size and produces flawed results (Beynon, 2024).

Methods matter: While two countries with identical per capita emissions in each year over any given time period will always have identical figures for (and therefore shares of) cumulative per capita emissions under method "a," whichever country's population grew faster during that period would have lower figures under method "b" and higher figures under method "c." Importantly, this holds true *regardless* of each country's initial population size (see Annex B).

Most previous analysis has focused on methods "a" and "b." For example, Carbon Brief have previously produced country-level estimates for the period 1850–2021 using methods "a" and "b," finding significant differences between the two.[30] Previous climate finance "fair share" models (including our own) have also tended to use either "a" or "b,"[31] though method "c" is arguably the fairest and most appropriate as a weighted average over time (a case can also be made for method "b," as some past emissions are embedded in our buildings and infrastructure from which current populations still benefit).

In the rest of this section, we test each approach using OWID data, estimating cumulative per capita emissions for each country using all three methods, and aggregating these into the Annex groups to calculate group shares in the same way as we have done for emissions. Results for the periods 1850–2024 and 1990–2024 are presented in figures 10 and 11, with the earlier OWID data on shares of *aggregate* emissions also shown for comparison.

30 Their analysis just covered CO_2 including LULUCF, but *both* methods found that several top 10 cumulative emitters—namely China, India, Brazil, and Indonesia—were missing from their lists of top 20 cumulative *per capita* emitters (Evans, 2021).

31 Method "a" was used by ODI in their identification of potential new contributors to the NCQG (Colenbrander et al, 2023) and is the approach used in the updated version of our own fair shares analysis (Beynon and Wickstead, 2024a), although we also incorporated population size to correct for the flaw noted above (we also introduced the facility to make the model more progressive by applying a minimum level of per capita emissions and/or income below which countries bear no responsibility [akin to a "tax free allowance"] and by applying exponents to both per capita emissions and income terms above those thresholds [akin to a progressive "tax"]. This is similar to the Climate Equity Reference Calculator, which excludes the emissions and incomes of individuals below a certain "development" threshold. Method "b" is the approach used by WRI in their own climate finance calculator scenarios using cumulative per capita emissions (Zou et al., 2024).

FIGURE 10. Shares of cumulative per capita emissions, 1850–2024

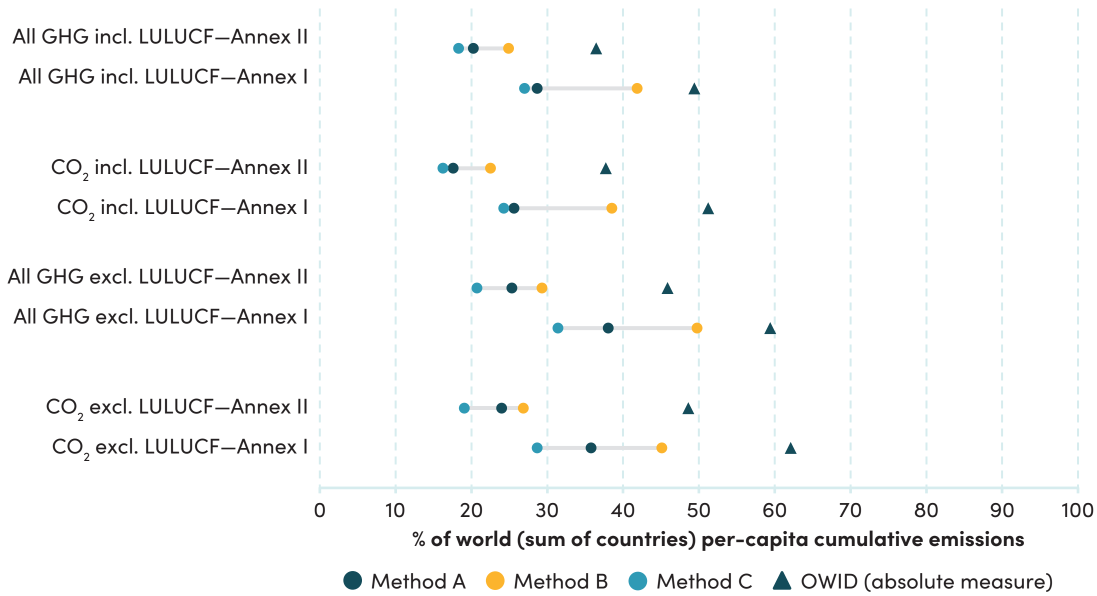
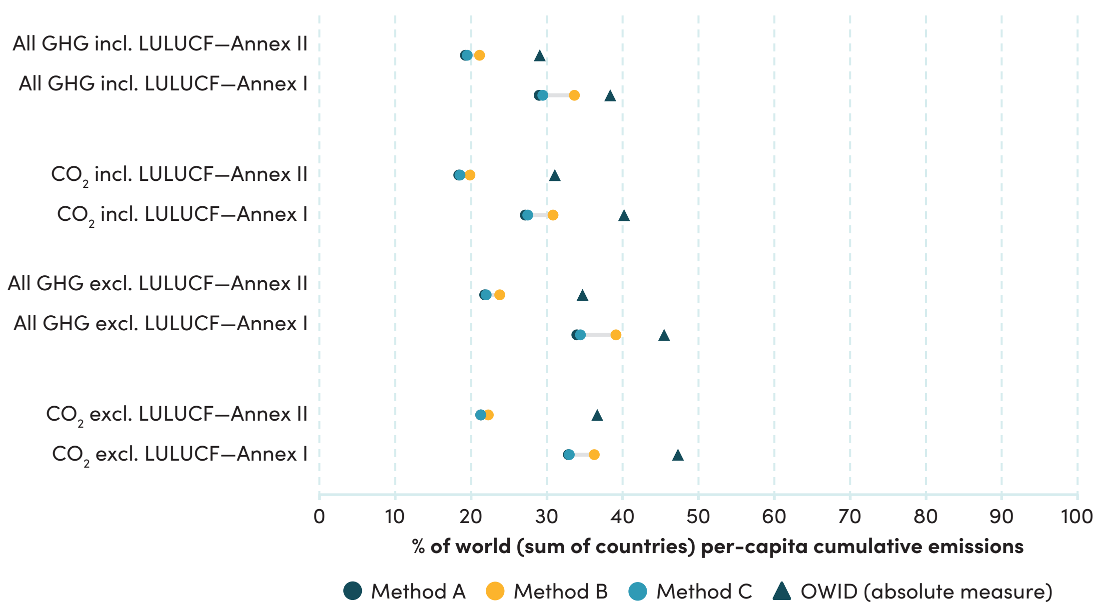


FIGURE 11. Shares of cumulative per capita emissions, 1990–2024



The key headline is that—whichever method we apply, and whichever time period or measure of emissions we use—developed country shares of cumulative per capita emissions are *lower* than for aggregate emissions overall, and often significantly so. Specifically, we find that:

- For the period 1850–2024, Annex II country shares of cumulative per capita emissions range between 15 and 30 percent across all four measures of emissions, with Annex I shares in the 25–50 percent range. These are typically 10–20 percentage points lower than OWID's comparable estimates of shares of aggregate emissions, differences being especially large for Annex II countries. Differences between the three methods are large, particularly for Annex I countries, with method "b" giving the highest estimates in each case, method "c" the lowest.

- For the period 1990–2024, Annex II country shares of cumulative per capita emissions range between 18 and 25 percent for all four measures of emissions, with Annex I shares in the 30–40 percent range. These are typically 5–15 percentage points lower than OWID's comparable estimates of shares of aggregate emissions, with differences again being especially large for Annex II countries. The three methods give more consistent results for this time period: method "b" still yields the highest, but those for methods "a" and "c" are almost identical.

These are perhaps surprising results, especially in the context of Figure 9, which shows average emissions per capita in developing countries have been consistently much lower than those in developed countries (either Annex I or Annex II). The explanation is that aggregations of per capita emissions are dependent on not just the level of emissions but also the number of countries in the group. To illustrate, imagine each Annex II country were split exactly in two such that Belgium A and Belgium B, for example, would each have half Belgium's emissions and half its population (but crucially, each would have the same, unchanged level of per capita emissions). Annex II's total emissions (and population) remain the same, and Annex II's share of total historical emissions would remain at 36 percent (for all GHGs including LULUCF, 1850–2024). But Annex II's share of cumulative per capita emissions would increase from 19–25 percent (across the three methods) to 32–40 percent, simply because the number of Annex II countries has doubled. We could potentially avoid this problem by doing our calculations at group, rather than country, level.[32] This would yield higher developed country shares, but is equally flawed in that individual countries within a group can have "shares" that are larger than the group of which they are a member (for example, the US's share would be larger than the share of Annex II countries overall, which is itself larger than the share of all Annex I countries: see also discussion in Annex B).

These results illustrate the difficulties of using and interpreting data on cumulative per capita emissions. They also reinforce the point that from the perspective of trying to identify which countries (and groups of countries) are most historically responsible for climate change, it is cumulative *aggregate* emissions that matter.

An alternative approach developed by Hickel (2020) is based on a principle of equal per capita access to atmospheric commons. He calculates national contributions to cumulative CO_2 emissions over the period 1850–2015 (territorial emissions 1850–1969, consumption emissions 1970–2015) that exceed national "fair shares", which are themselves derived by assigning equal per capita rights to a safe global emissions budget (set by a planetary boundary of 350 ppm atmospheric CO_2 concentration)

32 By aggregating emissions and population across the group before calculating per capita emissions, rather than calculating per capita emissions for individual countries and then aggregating into groups.

which was overshot in 1990. He finds that Annex I countries are responsible for 90 percent of the total global overshoot, with "Global North" countries (USA, Canada, Europe, Israel, Australia, New Zealand, and Japan) responsible for 92 percent. While his measure of emissions and truncated time period favour developing countries (Hickel notes for example that China will soon overshoot its fair share), and while his results have occasionally been misrepresented as the share of emissions rather than the overshoot, the approach does raise important ethical questions regarding per capita emissions.

Summary and conclusions

In summary, we find that:

- in spite of challenges and differences in approaches to counting GHG emissions that yield significant differences in total estimates, the different datasets are in fact reasonably consistent in their estimates of developed (and developing) country shares of cumulative emissions;
- developed countries using the UNFCCC's Annex I category are responsible for about half of all GHG emissions since 1850, and less than 40 percent if limited to the 23 Annex II countries with a formal obligation to provide climate finance;
- these shares are lower if we consider contributions to global warming rather than GHG emissions, being 46 percent for Annex I countries and 34 percent for Annex II countries;
- but they are higher if we restrict emissions to just CO_2, and higher again if we exclude LULUCF, with Annex I and II shares of CO_2 excluding LULUCF being 62 and 49 percent respectively;
- developed country shares are significantly lower across the board in the period since 1990, with Annex I and II shares of around 38 and 30 percent respectively for all GHGs including LULUCF, and around 47 and 36 percent respectively for CO_2 excluding LULUCF;
- taking account of colonial or consumption emissions makes little difference to our results;
- developed country shares of cumulative per capita emissions (not that we think this is an appropriate measure) are even lower than for cumulative emissions using three different calculation methods, ranging from 25 to 50 percent across the four measures of emissions for Annex I and 15 to 30 percent for Annex II since 1850. Figures since 1990 are 30–40 percent for Annex I and 18–25 percent for Annex II countries.

These figures are significantly lower than commonly perceived, but there are also other important ethical dimensions to the debate that need to be considered. We hope this analysis will inform ongoing discussions about historical emissions and their implications for future emissions reduction pathways and particularly the provision of climate finance.

Annex A. Comparative summary of greenhouse gas emissions datasets

	Global Carbon Budget (GCP)	PRIMAP-hist v2.7	EDGAR (2025 Report)	Climate Watch (WRI)	Our World in Data	Jones et al. (2025)
Years covered	1750–2025 (detailed from 1959; 2025 is a projection)	1750–2024 (most recent year partly extrapolated)	1970–2024	1990–2023	1750–2024 for CO_2; 1850–2024 for other GHGs	1830–2024 (emissions); 1851–2024 (cumulative & warming)
Gases covered	CO_2 only (fossil + land-use change)	All Kyoto gases: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3. Gas baskets provided using SAR, AR4, AR5, & AR6 GWPs	CO_2, CH_4, N_2O, F-gases (HFCs, PFCs, SF_6, NF_3). Totals use AR5 GWP100	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6. Totals use AR4 GWP100	CO_2, CH_4, N_2O, and total GHGs. Inherits from upstream sources (GCP, Jones et al.)	CO_2, CH_4, N_2O (no F-gases). Aggregated using GWP* from IPCC AR6
Sectors covered	Two components only: fossil CO_2 (fuel combustion + cement + flaring) and land-use change CO_2. No further sectoral breakdown	IPCC 2006 main categories: Energy (with subcategories), IPPU (with subcategories), Agriculture (livestock/non-livestock), Waste, Other. CO_2, CH_4, N_2O subsector data available for Energy, IPPU, and Agriculture	All anthropogenic sectors per IPCC: Energy, Industrial Processes, Agriculture, Waste. Gridded data also available at 0.1°×0.1° resolution	Energy, Industrial Processes, Agriculture, Waste, LULUCF. Follows IPCC 2006 structure with some adapted subcategories	No independent sectoral breakdown. CO_2 split into fossil and land-use change. For sectoral data, previously drew on Climate Watch/CAIT	Fossil vs. LULUCF source split only. No detailed sectoralbreakdown
LULUCF included?	Yes: land-use change CO_2 provided (model-derived via bookkeeping models: BLUE, OSCAR, H&N). National LULUCF estimates carry high uncertainty	**Excluded** from main file. Available separately in the “no rounding” file but unharmonised and to be used with care	Now included in the full dataset, but headline GHG summary table **excludes** LULUCF. LULUCF data available in supplementary files	Yes: sourced from FAOSTAT	Yes: land-use change CO_2 available from GCP. Total GHG figures from Jones et al. include LULUCF	Yes: fossil and LULUCF components reported separately for each gas and country
Primary/ underlying sources	Energy statistics (IEA, national agencies), CDIAC (historical), Andrew cement data, bookkeeping models (BLUE, OSCAR, H&N) for LULUCF	UNFCCC CRT/CRF (Annex I), BTRs/BURs/ NCs (non-Annex I), CDIAC, EI Statistical Review, Andrew cement data, FAOSTAT, EDGAR, EDGAR-HYDE, CEDS, RCP. Two scenarios: country-reported priority (HISTCR) vs. third-party priority (HISTTP)	IEA World Energy Balances & GHG Emissions from Energy (fossil CO_2, joint IEA-EDGAR), FAOSTAT (agriculture), USGS, World Steel, IFA, GFMR/NOAA (flaring), EI Statistical Review, IATA. Bottom-up, IPCC emission-factor methodology	Composite from: IEA (CO_2 fuel combustion), US EPA (non-CO_2 industrial & waste), FAOSTAT (agriculture, LULUCF), EDGAR (F-gases)	Secondary aggregator. CO_2 from GCP; CH_4, N_2O, & total GHGs from Jones et al. (previously Climate Watch). Per capita/GDP metrics use UN population, Maddison Project, EI, EIA	CO_2 from GCP; CH_4 & N_2O from PRIMAP-hist (HISTTP). Warming calculated using TCRE & GWP* coefficients from IPCC AR6

(Continued)

	Global Carbon Budget (GCP)	PRIMAP-hist v2.7	EDGAR (2025 Report)	Climate Watch (WRI)	Our World in Data	Jones et al. (2025)
Country coverage	~220 countries/ territories for fossil CO_2. National LULUCF estimates available but model-derived	Almost all UNFCCC members + most non-UNFCCC territories (incl. Taiwan). Precomputed groups: Annex I, non-Annex I, AOSIS, BASIC, EU27, LDCs, Umbrella Group	All world countries/ territories (200+). Some small territories grouped (e.g., France & Monaco, Italy & San Marino & Holy See)	193 countries + EU. Historical shares estimated for countries that did not exist in 1990 (e.g., former Soviet/Yugoslav states)	All countries in GCP (~220 for CO_2) and Jones et al. Standardised names. Precomputed regional & income-group aggregates	All countries with ISO 3166-1 alpha-3 codes. Groupings: Annex I, Annex II, EITs, LDCs, LMDC, OECD, EU27, BASIC
Missing data/gap filling	Projection for latest year using monthly energy data, GDP trends (IMF), proxy indicators. Historical gaps filled via growth rates from related datasets	Lower-priority sources harmonised to higher-priority. Latest year: linear extrapolation (5-yr trend, or 15-yr for energy CO_2). A "no extrapolation" variant is provided	"Fast Track" methodology produces t−1 estimates. Uses internationally harmonised statistics and consistent emission factors; does not rely on national submissions—so figures may differ from official inventories	US EPA interpolation between reported years or Tier 1 growth rates for non-Annex I gaps. Three-year lag is a practical constraint of source availability	Inherits gap filling from upstream sources (GCP, Jones et al.). Own processing limited to name standardisation, unit conversion, and derived metric computation	Inherits from GCP and PRIMAP-hist. No independent gap filling. Uses best-estimate TCRE and GWP* from IPCC AR6
International transport	International aviation & shipping reported as separate categories, not allocated to countries	Not included	International aviation & shipping reported separately, excluded from national totals	International bunkers excluded from national totals; not separately reported as a dedicated category	International aviation & shipping reported as separate entities (from GCP), not allocated to countries	Not included—not allocated in underlying data, therefore not reflected in national warming contributions
Web link	globalcarbonbudget.org Data: GCB Data Hub 2025	zenodo.org/records/ 17090760	edgar.jrc.ec.europa.eu/ report_2025	climatewatchdata. org/ghg-emissions Methods: WRI Technical Note	ourworldindata.org/ co2-and-greenhouse-gas-emissions Code/data: github. com/owid/co2-data	zenodo.org/ records/16640595 Paper: doi.org/ 10.1038/s41597-023-02041-1

Notes: GWP = Global Warming Potential; GWP* = an alternative CO_2-equivalence metric that relates changes in short-lived gas emissions to cumulative CO_2; TCRE = Transient Climate Response to Cumulative Emissions; GMST = Global Mean Surface Temperature; MRIO = Multi-Regional Input–Output; IPPU = Industrial Processes and Product Use; SAR/AR4/AR5/AR6 refer to IPCC Assessment Reports. This table was initially generated with the help of Claude Opus 4.6, but content was reviewed and edited by the authors.

Annex B. Calculating cumulative per capita emissions

There are three different ways of estimating cumulative emissions per capita:

a) Aggregating per capita emissions in each year of the period under consideration for each country. This effectively gives equal weight to the per capita emissions of both past and present populations, regardless of their size (akin to an *unweighted* average).
b) Aggregating total emissions for the period under consideration for each country and dividing by each country's current population. This effectively places the responsibility of all historical emissions on each country's current population.
c) Aggregating total emissions for the period under consideration for each country and dividing by the sum of that country's population in each year of the same time period. This differs from "a" above in that it is more akin to a *weighted* average, with more weight given to years when each country's population is larger.

While two countries with identical per capita emissions in each year over any given time period will always have identical figures for (and therefore shares of) cumulative per capita emissions under method "a," whichever country's population grew faster during that period would have lower figures under method "b" and higher figures under method "c." Importantly, this holds true *regardless* of each country's initial population size.

We can illustrate this using the following scenarios for countries A and B summarised in the table below. Figures and growth rates for per capita emissions, population, and total emissions are set out on the left-hand side. The right-hand side reports (for each of the three methods) results for cumulative per capita emissions, as well as shares of the combined total and ratios of the world average (recognising that the world average is not the same as the combined total of both countries).

Suppose country A has an initial (year 1) population of 1 million and per capita emissions of 0.5t/hd. Per capita emissions and population grow by 3 and 1 percent respectively per annum. After 100 years, GHGs/hd have risen to 9.3t/hd and population to 2.7 million. Cumulative per capita emissions over the 100-year period are 303, 236, and 3.7 t/hd respectively using the three methods. Another country B with identical characteristics would obviously have identical figures and each would be responsible for a 50 percent share of the combined total (with a figure equal to the world average, hence a ratio of 1), regardless of method (Scenario 1).

Suppose instead (Scenario 2) that country B's population growth is faster at 2 percent per annum, such that its population after 100 years is now more than seven times larger at 7.1m. B's aggregate cumulative emissions are obviously higher, but its cumulative emissions per capita are unchanged under method "a" and its share is still 50 percent. However, method "b" figures are lower (with a share of 44.9 percent), because while its total cumulative emissions have also increased (rising by 116 percent to 1,366 mtCO_2 cf. Scenario 1), its current population of 7.1m is 165 percent higher than in Scenario 1. Conversely, under method "c," its share rises to 54.1 percent, because that 116 percent increase in cumulative emissions is now larger than the 83 percent increase in B's *cumulative* population in Scenario 2 (312.2m) cf. Scenario 1 (170.5m).

Finally, suppose (Scenario 3) that not only does country B have faster population growth of 2 percent per annum but its initial population was higher at 3 million. All its figures for population and emissions are higher, but its per capita emissions are unchanged, and its share of total cumulative emissions per capita are the *same* as Scenario 2 using *all three methods* (and if we had only varied initial population size but not population growth rate, shares would have been the same as in Scenario 1, i.e., 50 percent for all three methods). Results for shares are therefore completely independent of initial population size. However, results for *ratios* (of the world average) do differ from Scenario 2, because while the cumulative per capita emissions of the two countries are individually (and hence also the "A+B cumulative GHG/hd figures) the same in both scenarios, the "world average cumulative GHG/hd" figures are different.

Comparing cumulative per capita emissions using three methods

Trends in GHGs/hd, Population, and Total Emissions					Cumulative GHG/hd Results Using 3 Alternative Methods			
	Growth Rate p.a.	Year 1	Year 100	Cumulative Total		Method		
						(a)	(b)	(c)
Scenario 1: Two identical countries								
Country A					**Country A**			
GHG/hd (tCO_2)	3.0%	0.5	9.3	303.6	Cumulative GHG/hd	303.6	236.2	3.7
Population (m)	1.0%	1	2.7	170.5	*– %share of A+B GHG/hd*	*50.0%*	*50.0%*	*50.0%*
Emissions ($mtCO_2$)		0.5	25.0	632.5	*– ratio of world avg GHG/hd*	*1.00*	*1.00*	*1.00*
Country B					**Country B**			
GHG/hd (tCO_2)	3.0%	0.5	9.3	303.6	Cumulative GHG/hd	303.6	236.2	3.7
Population (m)	1.0%	1	2.7	170.5	*– %share of A+B GHG/hd*	*50.0%*	*50.0%*	*50.0%*
Emissions ($mtCO_2$)		0.5	25.0	632.5	*– ratio of world avg GHG/hd*	*1.00*	*1.00*	*1.00*
World (A&B)					**World**			
GHG/hd (tCO_2)	3.0%	0.5	9.3	303.6	A+B cumulative GHG/hd	607.3	472.4	7.4
Population (m)	1.0%	2.0	5.4	341.0	Average cumulative GHG/hd	303.6	236.2	3.7
Emissions ($mtCO_2$)		1.0	50.0	1265.1				
Scenario 2: Faster population growth in Country B								
Country A					**Country A**			
GHG/hd (tCO_2)	3.0%	0.5	9.3	303.6	Cumulative GHG/hd	303.6	236.2	3.7
Population (m)	1.0%	1	2.7	170.5	*– %share of A+B GHG/hd*	*50.0%*	*55.1%*	*45.9%*
Emissions ($mtCO_2$)		0.5	25.0	632.5	*– ratio of world avg GHG/hd*	*1.00*	*1.16*	*0.90*

(Continued)

Trends in GHGs/hd, Population, and Total Emissions					Cumulative GHG/hd Results Using 3 Alternative Methods			
	Growth Rate p.a.	Year 1	Year 100	Cumulative Total		Method		
						(a)	(b)	(c)
Country B					**Country B**			
GHG/hd (tCO_2)	3.0%	0.5	9.3	303.6	Cumulative GHG/hd	303.6	192.3	4.4
Population (m)	2.0%	1	7.1	312.2	*– %share of A+B GHG/hd*	*50.0%*	*44.9%*	*54.1%*
Emissions ($mtCO_2$)		0.5	66.3	1365.9	*– ratio of world avg GHG/hd*	*1.00*	*0.94*	*1.06*
World (A&B)					**World**			
GHG/hd (tCO_2)	3.0%	0.5	9.3	303.6	A+B cumulative GHG/hd	607.3	428.5	8.1
Population (m)	1.6%	2.0	9.8	482.7	Average cumulative GHG/hd	303.6	204.3	4.1
Emissions ($mtCO_2$)		1.0	91.2	1998.5				
Scenario 3: Faster population growth and higher initial population in Country B								
Country A					**Country A**			
GHG/hd (tCO_2)	3.0%	0.5	9.3	303.6	Cumulative GHG/hd	303.6	236.2	3.7
Population (m)	1.0%	1	2.7	170.5	*– %share of A+B GHG/hd*	*50.0%*	*55.1%*	*45.9%*
Emissions ($mtCO_2$)		0.5	25.0	632.5	*– ratio of world avg GHG/hd*	*1.00*	*1.20*	*0.87*
Country B					**Country B**			
GHG/hd (tCO_2)	3.0%	0.5	9.3	303.6	Cumulative GHG/hd	303.6	192.3	4.4
Population (m)	2.0%	**3**	21.3	936.7	*– %share of A+B GHG/hd*	*50.0%*	*44.9%*	*54.1%*
Emissions ($mtCO_2$)		1.5	198.8	4097.8	*– ratio of world avg GHG/hd*	*1.00*	*0.98*	*1.02*
World (A&B)					**World**			
GHG/hd (tCO_2)	3.0%	0.5	9.3	303.6	A+B cumulative GHG/hd	607.3	428.5	8.1
Population (m)	1.8%	4.0	24.0	1107.2	Average cumulative GHG/hd	303.6	197.2	4.3
Emissions ($mtCO_2$)		2.0	223.8	4730.3				

One other point worth noting to illustrate the care that needs to be taken when undertaking and interpreting these calculations: in all scenarios above, the world average figures for cumulative emissions per head in the right-hand side of the table are just that—averages (weighted by population in year 100 for method "b" and by cumulative population for method "c"). That is why it is necessary to calculate each country's share of the world total using the sum of each country's figures (and *not* the world average) as the denominator. If the world average is used, then the "shares" of individual countries can exceed 100 percent (which is why the bottom rows in each element of the table above are expressed as *ratios*, not shares, of the world average), and comparing shares of groups of countries also becomes problematic.

Our estimates of Annex I shares are derived therefore by calculating per capita emissions for individual countries, aggregating these into Annex groups, and calculating each group's share as the sum of all individual countries (in the same way as done for aggregate emissions). We would get very different results if we were to calculate cumulative per capita emissions for each group as a collective, e.g., by dividing the sum of all annual Annex I emissions by the sum of all annual Annex I populations. Each group 'total' would then be a weighted average which, though useful context, would be inappropriate for calculating shares—we would end up with the bizarre result that subsets of each group would have higher shares than the group as a whole. To take all GHGs including LULUCF from 1850–2024 (OWID) as an example, Annex I's weighted average cumulative per capita emissions is 12.7 tCO_2e, with the figure for all non-Annex I countries being 4.4 tCO_2e, implying an Annex I share of 74 percent of the total, and Annex II's figure of 13.7 tCO_2e (cf. a non-Annex II figure of 5.0 tCO_2e) works out at 73 percent. But the US's figure of 24.8 tCO_2e (cf. a non-US figure of 5.6 tCO_2e) works out at 82 percent of the total. Note also that, for the same ratios vs shares reason as above for individual countries, the denominator for group calculations must be the sum of groups rather than the world average.

Annex C. Detailed tables of GHG emissions and shares for different country groups

The following tables present figures for global emissions (with and without international transport where available) estimated by each dataset and the shares (of global total excluding international transport) accounted for by various country groups, for each of the four measures of emissions (all GHGs or just CO_2, with and without LULUCF).

Tables C1–C4: 1850–2024;

Tables C5–C8: 1990–2024;

Tables C9–C12: 1850–2024, with colonial adjustment.

TABLE C1. GHG inc LULUCF | Cumulative 1850–2024

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**3609.37**	**3175.09**	**1.678**
World (country-attributable) ($GtCO_2e$)	**3608.25**	**3175.09**	**1.678**
By institutional group			
Annex I	49.4%	51.0%	46.4%
Annex II	36.4%	39.5%	34.3%
Annex II + other EU Members	39.5%	42.8%	36.9%
Non-Annex I	50.6%	49.0%	53.6%
OECD	42.6%	46.1%	40.3%
EU	11.9%	13.3%	10.5%
BRICS	30.7%	31.0%	31.0%
G7	31.4%	34.1%	29.5%
G20	70.8%	73.9%	69.8%
Non-Annex I G20 members	29.9%	32.2%	31.0%
By income group			
HIC	50.0%	50.9%	47.4%
UMIC	33.9%	35.4%	35.4%
LMIC	12.8%	11.6%	13.5%
LIC	3.3%	2.1%	3.7%
By development group			
LDC	5.5%	3.5%	6.1%
LLDC	4.1%	3.4%	4.5%
SIDS	0.7%	0.4%	0.7%
LIC/LMIC/SIDS/LDC	16.6%	14.0%	17.7%
By region			
Europe and Central Asia	26.8%	27.2%	24.4%
North America	20.5%	21.5%	19.9%
Latin America & Caribbean	10.9%	9.8%	11.5%
East Asia & Pacific	25.2%	26.4%	25.8%
South Asia	5.6%	5.8%	5.4%
Middle East & North Africa	4.5%	4.7%	5.3%
Sub-Saharan Africa	6.6%	4.5%	7.6%

(Continued)

TABLE C1. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GMST (°C/%)
G20 countries			
Argentina	0.9%	0.9%	1.0%
Australia	1.5%	1.6%	1.5%
Brazil	4.8%	4.6%	5.3%
Canada	2.3%	2.0%	2.3%
China	12.6%	15.1%	13.0%
France	1.6%	1.8%	1.3%
Germany	3.3%	3.8%	2.9%
India	4.9%	5.2%	4.8%
Indonesia	3.1%	2.5%	3.3%
Italy	1.0%	1.1%	0.9%
Japan	2.3%	2.5%	2.1%
Mexico	1.2%	1.5%	1.3%
Russia	7.4%	5.2%	7.0%
Saudi Arabia	0.7%	0.6%	0.8%
South Africa	0.9%	1.0%	1.0%
South Korea	0.7%	0.8%	0.7%
Turkey	0.7%	0.8%	0.7%
United Kingdom	2.8%	3.3%	2.4%
United States	18.2%	19.5%	17.7%

TABLE C2. GHG exc LULUCF | Cumulative 1850–2024

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**2205.73**	**2735.70**	**1.051**
World (country-attributable) ($GtCO_2e$)	**2204.54**	**2735.70**	**1.051**
By institutional group			
Annex I	59.4%	56.2%	55.9%
Annex II	45.9%	43.0%	42.8%
Annex II + other EU Members	49.8%	46.6%	46.3%
Non-Annex I	40.6%	43.8%	44.1%
OECD	52.6%	49.4%	49.3%
EU	16.0%	15.2%	14.4%
BRICS	28.8%	29.8%	29.8%
G7	40.7%	37.4%	37.8%
G20	76.4%	74.4%	75.2%
Non-Annex I G20 members	26.9%	28.4%	28.5%
By income group			
HIC	61.1%	56.8%	58.0%
UMIC	30.0%	31.2%	32.1%
LMIC	7.9%	9.9%	8.6%
LIC	1.0%	2.1%	1.2%

(Continued)

TABLE C2. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GMST (°C/%)
By development group			
LDC	1.1%	2.9%	1.5%
LLDC	2.2%	3.2%	2.4%
SIDS	0.5%	0.5%	0.6%
LIC / LMIC / SIDS / LDC	9.4%	12.5%	10.4%
By region			
Europe and Central Asia	32.0%	31.0%	29.8%
North America	24.7%	22.9%	23.7%
Latin America & Caribbean	4.9%	6.3%	5.2%
East Asia & Pacific	25.0%	25.1%	26.2%
South Asia	4.2%	5.4%	4.2%
Middle East & North Africa	6.1%	5.3%	7.1%
Sub-Saharan Africa	3.1%	3.9%	3.9%
G20 countries			
Argentina	0.5%	0.8%	0.5%
Australia	1.1%	1.3%	1.2%
Brazil	1.2%	2.0%	1.5%
Canada	2.0%	1.8%	2.0%
China	15.5%	15.3%	16.2%
France	2.2%	2.3%	1.9%
Germany	4.8%	4.3%	4.4%
India	3.9%	4.9%	3.9%
Indonesia	1.2%	1.3%	1.6%
Italy	1.3%	1.3%	1.3%
Japan	3.4%	2.9%	3.1%
Mexico	1.2%	1.3%	1.3%
Russia	7.0%	6.6%	6.9%
Saudi Arabia	1.1%	0.7%	1.2%
South Africa	1.2%	1.1%	1.3%
South Korea	1.0%	1.0%	1.0%
Turkey	0.7%	0.7%	0.8%
United Kingdom	4.1%	3.7%	3.4%
United States	22.8%	21.1%	21.7%

TABLE C3. CO_2 inc LULUCF | Cumulative 1850–2024

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GCP BLUE	GCP OSCAR	GCP LUCE	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**2902.72**	**2249.25**	**2902.72**	**2619.87**	**2727.37**	**1.216**
World (country-attributable) ($GtCO_2e$)	**2856.84**	**2249.25**	**2856.36**	**2573.51**	**2681.01**	**1.216**
By institutional group						
Annex I	51.2%	53.7%	51.2%	52.0%	53.9%	52.3%
Annex II	37.7%	42.3%	37.7%	40.2%	39.5%	39.1%
Annex II + other EU Members	40.5%	45.8%	40.5%	43.1%	42.6%	42.0%
Non-Annex I	48.8%	46.3%	48.8%	48.0%	46.1%	47.7%
OECD	43.8%	49.3%	43.8%	46.5%	45.7%	45.3%
EU	11.2%	14.0%	11.2%	12.2%	12.1%	11.8%
BRICS	30.6%	30.6%	30.6%	29.0%	30.5%	30.1%
G7	33.2%	37.3%	33.2%	35.3%	34.9%	34.4%
G20	72.6%	76.6%	72.6%	73.2%	73.8%	73.2%
Non-Annex I G20 members	29.4%	32.2%	29.4%	29.3%	28.3%	29.0%
By income group						
HIC	51.8%	53.8%	51.8%	53.2%	54.7%	53.2%
UMIC	34.0%	35.7%	34.0%	34.8%	33.1%	33.9%
LMIC	11.2%	9.6%	11.2%	9.6%	9.4%	10.1%
LIC	3.0%	0.8%	3.0%	2.3%	2.7%	2.7%
By development group						
LDC	5.1%	1.8%	5.1%	4.0%	4.3%	4.5%
LLDC	3.4%	2.5%	3.4%	4.1%	3.1%	3.5%
SIDS	0.8%	0.3%	0.8%	0.7%	0.7%	0.7%
LIC/LMIC/SIDS/LDC	14.8%	10.7%	14.8%	12.5%	12.7%	13.4%
By region						
Europe and Central Asia	26.5%	27.8%	26.5%	27.0%	28.3%	27.2%
North America	22.3%	23.3%	22.3%	23.0%	23.3%	22.8%
Latin America & Caribbean	10.8%	9.3%	10.8%	11.8%	10.1%	10.9%
East Asia & Pacific	25.9%	27.5%	25.9%	26.2%	25.7%	25.9%
South Asia	4.2%	4.7%	4.2%	3.5%	3.6%	3.8%
Middle East & North Africa	3.7%	4.3%	3.6%	3.6%	3.7%	3.7%
Sub-Saharan Africa	6.7%	2.9%	6.7%	4.9%	5.3%	5.7%

(Continued)

TABLE C3. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GCP BLUE	GCP OSCAR	GCP LUCE	GMST (°C/%)
G20 countries						
Argentina	0.8%	0.6%	0.8%	0.7%	0.7%	0.8%
Australia	1.2%	1.4%	1.2%	1.4%	1.0%	1.2%
Brazil	4.9%	4.6%	4.9%	5.6%	4.7%	5.0%
Canada	2.7%	2.3%	2.7%	2.3%	2.7%	2.5%
China	12.8%	15.7%	12.8%	12.6%	12.7%	12.7%
France	1.3%	1.7%	1.3%	1.6%	1.4%	1.4%
Germany	3.3%	4.4%	3.3%	3.7%	3.6%	3.5%
India	3.8%	4.3%	3.8%	3.2%	3.2%	3.4%
Indonesia	3.4%	2.7%	3.4%	3.4%	3.4%	3.4%
Italy	0.9%	1.2%	0.9%	1.0%	1.0%	1.0%
Japan	2.6%	3.1%	2.6%	2.8%	2.7%	2.7%
Mexico	1.3%	1.5%	1.3%	1.2%	1.1%	1.2%
Russia	8.1%	5.0%	8.1%	6.6%	8.9%	7.9%
Saudi Arabia	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
South Africa	1.1%	1.1%	1.1%	1.0%	0.9%	1.0%
South Korea	0.7%	0.9%	0.7%	0.8%	0.8%	0.8%
Turkey	0.7%	0.8%	0.7%	0.5%	0.6%	0.6%
United Kingdom	2.8%	3.6%	2.8%	3.1%	2.9%	2.9%
United States	19.6%	21.0%	19.6%	20.7%	20.6%	20.3%

TABLE C4. CO_2 exc LULUCF | Cumulative 1850–2024

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GCP Fossil	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**1844.55**	**1862.25**	**1844.55**	**0.810**
World (country-attributable) ($GtCO_2e$)	**1798.67**	**1862.25**	**1798.19**	**0.810**
By institutional group				
Annex I	62.1%	62.2%	62.1%	62.1%
Annex II	48.6%	48.5%	48.6%	48.6%
Annex II + other EU Members	52.5%	52.4%	52.5%	52.5%
Non-Annex I	37.9%	37.8%	37.9%	37.9%
OECD	55.4%	55.2%	55.4%	55.4%
EU	16.7%	16.8%	16.7%	16.7%
BRICS	28.6%	28.7%	28.6%	28.6%
G7	43.2%	42.9%	43.2%	43.2%
G20	78.6%	78.2%	78.6%	78.6%
Non-Annex I G20 members	26.7%	26.6%	26.7%	26.7%
By income group				
HIC	63.8%	63.4%	63.8%	63.7%
UMIC	29.1%	29.3%	29.1%	29.1%
LMIC	6.5%	6.4%	6.5%	6.5%
LIC	0.6%	0.7%	0.6%	0.6%

(Continued)

TABLE C4. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GCP Fossil	GMST (°C/%)
By development group				
LDC	0.5%	0.5%	0.5%	0.5%
LLDC	2.0%	2.0%	2.0%	2.0%
SIDS	0.5%	0.4%	0.5%	0.5%
LIC/LMIC/SIDS/LDC	7.6%	7.6%	7.6%	7.6%
By region				
Europe and Central Asia	32.8%	33.4%	32.9%	32.8%
North America	26.2%	25.9%	26.2%	26.2%
Latin America & Caribbean	4.3%	4.2%	4.3%	4.3%
East Asia & Pacific	25.7%	25.7%	25.7%	25.7%
South Asia	3.8%	3.8%	3.8%	3.8%
Middle East & North Africa	5.2%	5.1%	5.1%	5.1%
Sub-Saharan Africa	2.0%	1.9%	2.0%	2.0%
G20 countries				
Argentina	0.5%	0.5%	0.5%	0.5%
Australia	1.1%	1.1%	1.1%	1.1%
Brazil	1.0%	1.0%	1.0%	1.0%
Canada	2.0%	1.9%	2.0%	2.0%
China	15.8%	15.8%	15.9%	15.9%
France	2.2%	2.2%	2.2%	2.2%
Germany	5.3%	5.3%	5.3%	5.3%
India	3.7%	3.6%	3.7%	3.7%
Indonesia	1.0%	1.0%	1.0%	1.0%
Italy	1.4%	1.5%	1.4%	1.4%
Japan	3.9%	3.8%	3.9%	3.9%
Mexico	1.2%	1.3%	1.2%	1.2%
Russia	6.8%	7.0%	6.8%	6.8%
Saudi Arabia	1.1%	0.9%	1.1%	1.1%
South Africa	1.3%	1.3%	1.3%	1.3%
South Korea	1.2%	1.2%	1.2%	1.2%
Turkey	0.7%	0.7%	0.7%	0.7%
United Kingdom	4.3%	4.2%	4.3%	4.2%
United States	24.2%	24.0%	24.2%	24.2%

TABLE C5. GHG inc LULUCF | Cumulative 1990–2024

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	EDGAR 2025	Climate Watch	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**1615.39**	**1322.81**	**1536.56**	**1414.59**	**0.712**
World (country-attributable) ($GtCO_2e$)	**1614.80**	**1322.81**	**1500.62**	**1368.53**	**0.712**
By institutional group					
Annex I	38.4%	38.8%	36.0%	37.1%	32.6%
Annex II	29.1%	32.2%	29.7%	29.7%	25.1%
Annex II + other EU Members	31.2%	34.5%	31.8%	31.9%	26.2%
Non-Annex I	61.6%	61.2%	64.0%	62.9%	67.4%

(Continued)

TABLE C5. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	EDGAR 2025	Climate Watch	GMST (°C/%)
OECD	35.1%	38.7%	35.3%	36.0%	30.5%
EU	8.9%	10.2%	9.3%	9.4%	6.6%
BRICS	36.6%	36.4%	35.1%	34.3%	38.9%
G7	24.5%	27.5%	24.7%	25.0%	21.1%
G20	71.6%	74.8%	72.6%	70.4%	71.2%
Non-Annex I G20 members	39.6%	42.8%	42.9%	39.9%	43.1%
By income group					
HIC	41.2%	41.5%	39.1%	39.4%	36.1%
UMIC	41.3%	43.6%	42.0%	42.8%	44.1%
LMIC	13.8%	13.0%	15.9%	13.7%	15.3%
LIC	3.6%	1.9%	2.9%	4.1%	4.5%
By development group					
LDC	5.6%	3.0%	4.7%	5.9%	7.0%
LLDC	3.9%	3.2%	4.6%	4.3%	4.6%
SIDS	0.7%	0.1%	0.3%	0.6%	0.7%
LIC/LMIC/SIDS/LDC	17.9%	15.0%	19.1%	18.3%	20.3%
By region					
Europe and Central Asia	19.3%	18.5%	16.8%	18.4%	15.5%
North America	16.3%	17.6%	16.1%	16.1%	14.7%
Latin America & Caribbean	11.2%	9.2%	7.8%	11.2%	11.9%
East Asia & Pacific	32.7%	35.9%	37.0%	32.7%	35.2%
South Asia	6.2%	6.2%	8.7%	6.4%	6.5%
Middle East & North Africa	6.9%	7.9%	7.7%	7.8%	7.4%
Sub-Saharan Africa	7.3%	4.8%	6.0%	7.5%	8.8%
G20 countries					
Argentina	0.9%	1.0%	0.7%	1.0%	0.7%
Australia	1.5%	1.5%	2.0%	1.6%	1.3%
Brazil	5.8%	4.9%	4.2%	4.8%	6.5%
Canada	1.9%	2.0%	1.1%	2.1%	1.9%
China	18.8%	22.4%	19.7%	19.4%	20.7%
France	1.0%	1.2%	1.2%	1.1%	0.7%
Germany	2.1%	2.6%	2.4%	2.2%	1.5%
India	5.7%	5.7%	7.7%	5.8%	5.9%
Indonesia	3.5%	3.4%	5.6%	3.7%	4.1%
Italy	1.0%	1.2%	1.0%	1.1%	0.9%
Japan	2.7%	3.2%	2.5%	2.9%	2.5%
Mexico	1.4%	1.5%	1.1%	1.5%	1.5%
Russia	5.1%	2.2%	2.1%	3.2%	4.7%
Saudi Arabia	1.2%	1.2%	1.2%	1.2%	1.4%
South Africa	1.2%	1.3%	1.5%	1.1%	1.2%
South Korea	1.2%	1.5%	1.3%	1.3%	1.2%
Turkey	0.9%	0.8%	0.8%	0.8%	1.0%
United Kingdom	1.3%	1.7%	1.5%	1.6%	0.8%
United States	14.4%	15.6%	15.0%	14.0%	12.8%

TABLE C6. GHG exc LULUCF | Cumulative 1990–2024

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	EDGAR 2025	Climate Watch	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**1214.53**	**1405.03**	**1475.24**	**1382.25**	**0.551**
World (country-attributable) ($GtCO_2e$)	**1213.91**	**1405.03**	**1439.30**	**1336.44**	**0.551**
By institutional group					
Annex I	45.5%	43.2%	42.4%	42.8%	40.6%
Annex II	34.7%	33.2%	32.0%	32.3%	30.6%
Annex II + other EU Members	37.3%	35.7%	34.5%	34.8%	32.3%
Non-Annex I	54.5%	56.8%	57.6%	57.2%	59.4%
OECD	41.5%	39.9%	38.6%	39.0%	36.9%
EU	10.8%	10.3%	10.2%	10.2%	8.7%
BRICS	36.9%	37.1%	38.0%	36.7%	39.8%
G7	29.9%	28.5%	27.2%	27.3%	26.2%
G20	76.0%	74.6%	74.1%	73.5%	76.2%
Non-Annex I G20 members	37.9%	38.7%	39.1%	38.0%	41.6%
By income group					
HIC	49.4%	46.1%	45.8%	45.2%	44.7%
UMIC	39.3%	40.2%	39.8%	39.7%	42.7%
LMIC	10.3%	11.5%	12.5%	12.9%	11.2%
LIC	1.1%	2.1%	1.9%	2.3%	1.4%
By development group					
LDC	1.4%	3.0%	2.8%	3.3%	2.1%
LLDC	2.2%	3.2%	2.9%	3.5%	2.4%
SIDS	0.6%	0.6%	0.6%	0.5%	0.6%
LIC / LMIC / SIDS / LDC	11.9%	14.2%	14.9%	15.7%	13.2%
By region					
Europe and Central Asia	22.7%	21.6%	21.8%	22.2%	20.0%
North America	19.7%	18.8%	17.7%	17.9%	17.7%
Latin America & Caribbean	5.5%	7.0%	7.1%	7.6%	6.0%
East Asia & Pacific	34.6%	34.5%	34.4%	32.8%	37.7%
South Asia	5.7%	6.1%	6.7%	6.8%	6.0%
Middle East & North Africa	8.2%	7.5%	7.7%	8.0%	8.3%
Sub-Saharan Africa	3.6%	4.4%	4.5%	4.7%	4.2%
G20 countries					
Argentina	0.5%	0.7%	0.8%	0.9%	0.5%
Australia	1.3%	1.3%	1.4%	1.5%	1.3%
Brazil	1.6%	2.4%	2.5%	2.4%	1.8%
Canada	1.9%	1.8%	1.8%	1.7%	1.9%
China	22.7%	22.7%	22.4%	21.2%	24.9%
France	1.2%	1.2%	1.2%	1.2%	1.0%
Germany	2.6%	2.4%	2.4%	2.3%	2.0%

(Continued)

TABLE C6. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	EDGAR 2025	Climate Watch	GMST (°C/%)
India	5.4%	5.6%	6.2%	6.2%	5.6%
Indonesia	1.7%	1.7%	1.7%	1.9%	2.4%
Italy	1.3%	1.2%	1.2%	1.2%	1.2%
Japan	3.6%	3.2%	3.2%	3.2%	3.3%
Mexico	1.5%	1.6%	1.5%	1.5%	1.6%
Russia	5.8%	5.2%	5.6%	5.7%	5.9%
Saudi Arabia	1.6%	1.2%	1.3%	1.3%	1.7%
South Africa	1.4%	1.2%	1.3%	1.2%	1.5%
South Korea	1.6%	1.5%	1.4%	1.5%	1.5%
Turkey	1.0%	1.0%	0.9%	0.9%	1.3%
United Kingdom	1.6%	1.6%	1.5%	1.6%	0.9%
United States	17.8%	17.1%	16.0%	16.2%	15.8%

TABLE C7. CO_2 inc LULUCF | Cumulative 1990–2024

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	EDGAR 2025	Climate Watch	GCP BLUE	GCP OSCAR	GCP LUCE	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**1295.45**	**950.32**	**1106.80**	**1004.78**	**1295.45**	**1257.23**	**1265.10**	**0.559**
World (country-attributable) ($GtCO_2e$)	**1263.56**	**950.32**	**1072.27**	**961.45**	**1263.08**	**1224.86**	**1232.73**	**0.559**
By institutional group								
Annex I	40.2%	41.0%	38.3%	40.2%	40.2%	40.5%	42.0%	40.9%
Annex II	31.1%	35.0%	32.8%	33.4%	31.1%	31.4%	31.8%	31.4%
Annex II + other EU Members	33.0%	37.4%	35.0%	35.8%	33.1%	33.6%	34.0%	33.5%
Non-Annex I	59.8%	59.0%	61.7%	59.8%	59.8%	59.5%	58.0%	59.1%
OECD	37.0%	41.8%	38.4%	40.1%	37.0%	37.6%	37.9%	37.5%
EU	9.0%	11.2%	10.2%	10.5%	9.0%	9.6%	9.4%	9.3%
BRICS	37.0%	37.1%	35.8%	34.9%	37.0%	36.8%	37.7%	37.1%
G7	26.6%	30.3%	27.7%	28.8%	26.7%	27.1%	27.2%	27.0%
G20	74.2%	78.7%	77.3%	74.6%	74.2%	74.5%	75.4%	74.7%
Non-Annex I G20 members	40.2%	44.6%	45.5%	41.2%	40.2%	40.4%	40.0%	40.2%
By income group								
HIC	43.5%	44.4%	41.8%	42.9%	43.5%	43.8%	45.4%	44.2%
UMIC	41.5%	44.3%	43.7%	43.7%	41.5%	42.6%	41.6%	41.9%
LMIC	11.7%	11.1%	13.4%	10.3%	11.7%	11.1%	10.3%	11.1%
LIC	3.2%	0.2%	1.1%	3.0%	3.2%	2.5%	2.7%	2.8%
By development group								
LDC	4.8%	0.6%	1.4%	4.1%	4.8%	3.9%	3.9%	4.2%
LLDC	3.3%	1.8%	3.4%	3.0%	3.3%	3.2%	2.7%	3.1%
SIDS	0.7%	-0.1%	0.2%	0.6%	0.7%	0.7%	0.7%	0.7%
LIC/LMIC/SIDS/LDC	15.5%	11.2%	14.6%	13.8%	15.5%	14.1%	13.6%	14.4%

(Continued)

TABLE C7. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	EDGAR 2025	Climate Watch	GCP BLUE	GCP OSCAR	GCP LUCE	GMST (°C/%)
By region								
Europe and Central Asia	19.2%	18.8%	16.9%	18.6%	19.2%	20.2%	20.5%	19.9%
North America	17.6%	18.5%	17.7%	18.2%	17.6%	17.7%	18.1%	17.8%
Latin America & Caribbean	10.5%	7.6%	5.9%	10.1%	10.6%	11.1%	10.3%	10.7%
East Asia & Pacific	34.8%	38.8%	41.0%	35.2%	34.8%	34.5%	34.8%	34.7%
South Asia	5.1%	5.8%	8.6%	5.1%	5.1%	5.0%	4.9%	5.0%
Middle East & North Africa	6.1%	7.9%	7.3%	7.0%	6.1%	6.2%	6.2%	6.1%
Sub-Saharan Africa	6.7%	2.5%	2.6%	5.8%	6.7%	5.4%	5.2%	5.7%
G20 countries								
Argentina	0.8%	0.8%	0.4%	0.8%	0.8%	0.5%	0.8%	0.7%
Australia	1.3%	1.4%	2.0%	1.3%	1.3%	1.2%	1.3%	1.3%
Brazil	5.6%	4.5%	3.6%	4.8%	5.6%	6.2%	5.6%	5.8%
Canada	2.0%	2.1%	0.8%	2.4%	2.0%	1.8%	2.1%	2.0%
China	20.1%	24.2%	21.7%	21.6%	20.1%	19.7%	20.3%	20.1%
France	1.0%	1.2%	1.2%	1.1%	1.0%	1.1%	0.8%	1.0%
Germany	2.3%	3.1%	2.8%	2.8%	2.3%	2.4%	2.4%	2.4%
India	4.8%	5.5%	7.6%	4.8%	4.8%	4.8%	4.6%	4.7%
Indonesia	3.5%	3.7%	6.6%	3.6%	3.5%	4.0%	3.5%	3.7%
Italy	1.1%	1.4%	1.2%	1.3%	1.1%	1.2%	1.1%	1.1%
Japan	3.3%	4.1%	3.2%	3.7%	3.3%	3.3%	3.4%	3.3%
Mexico	1.4%	1.3%	0.9%	1.4%	1.4%	1.4%	1.3%	1.4%
Russia	5.2%	1.5%	1.1%	2.4%	5.2%	4.9%	6.1%	5.4%
Saudi Arabia	1.3%	1.5%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%
South Africa	1.3%	1.4%	1.7%	1.2%	1.3%	1.2%	1.2%	1.2%
South Korea	1.4%	1.8%	1.6%	1.6%	1.4%	1.4%	1.4%	1.4%
Turkey	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%
United Kingdom	1.4%	1.8%	1.7%	1.7%	1.4%	1.5%	1.4%	1.4%
United States	15.6%	16.4%	16.9%	15.8%	15.6%	15.9%	16.0%	15.8%

TABLE C8. CO_2 exc LULUCF | Cumulative 1990–2024

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	EDGAR 2025	Climate Watch	GCP Fossil	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**1064.77**	**1043.83**	**1082.88**	**981.61**	**1064.77**	**0.465**
World (country-attributable) ($GtCO_2e$)	**1032.87**	**1043.83**	**1048.35**	**938.51**	**1032.39**	**0.465**
By institutional group						
Annex I	47.3%	46.7%	46.4%	48.1%	47.3%	47.3%
Annex II	36.6%	36.2%	35.3%	37.0%	36.6%	36.6%
Annex II + other EU Members	39.3%	38.8%	38.0%	39.7%	39.3%	39.3%
Non-Annex I	52.7%	53.3%	53.6%	51.9%	52.7%	52.7%
OECD	43.6%	43.2%	42.2%	44.1%	43.6%	43.6%
EU	11.4%	11.3%	11.2%	11.5%	11.4%	11.4%
BRICS	37.5%	38.0%	38.9%	38.0%	37.5%	37.5%
G7	31.7%	31.3%	30.5%	32.0%	31.7%	31.7%
G20	78.1%	78.2%	78.0%	78.9%	78.2%	78.1%
Non-Annex I G20 members	38.4%	39.0%	39.2%	38.5%	38.5%	38.5%
By income group						
HIC	51.3%	50.4%	50.2%	50.8%	51.3%	51.2%
UMIC	38.9%	39.6%	39.9%	39.2%	38.9%	38.9%
LMIC	9.2%	9.3%	9.3%	9.3%	9.2%	9.2%
LIC	0.6%	0.7%	0.6%	0.6%	0.6%	0.6%
By development group						
LDC	0.7%	0.8%	0.7%	0.7%	0.7%	0.7%
LLDC	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%
SIDS	0.6%	0.5%	0.6%	0.5%	0.6%	0.6%
LIC/LMIC/SIDS/LDC	10.4%	10.4%	10.5%	10.4%	10.4%	10.3%
By region						
Europe and Central Asia	23.3%	23.0%	23.4%	23.8%	23.3%	23.2%
North America	20.5%	20.2%	19.5%	20.6%	20.5%	20.5%
Latin America & Caribbean	5.1%	5.1%	5.0%	5.0%	5.1%	5.1%
East Asia & Pacific	35.9%	36.6%	37.0%	35.5%	35.9%	35.9%
South Asia	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%
Middle East & North Africa	7.4%	7.2%	7.1%	7.2%	7.3%	7.3%
Sub-Saharan Africa	2.3%	2.3%	2.3%	2.3%	2.3%	2.3%
G20 countries						
Argentina	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Australia	1.2%	1.2%	1.2%	1.3%	1.2%	1.2%
Brazil	1.3%	1.4%	1.3%	1.3%	1.3%	1.3%
Canada	1.8%	1.8%	1.8%	1.9%	1.8%	1.8%
China	23.6%	24.3%	24.7%	24.0%	23.7%	23.6%
France	1.2%	1.3%	1.2%	1.2%	1.2%	1.2%
Germany	2.8%	2.8%	2.7%	2.9%	2.8%	2.8%
India	5.4%	5.4%	5.4%	5.3%	5.4%	5.4%

(Continued)

TABLE C8. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	EDGAR 2025	Climate Watch	GCP Fossil	GMST (°C/%)
Indonesia	1.4%	1.5%	1.4%	1.4%	1.4%	1.4%
Italy	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%
Japan	4.1%	4.0%	4.0%	4.1%	4.1%	4.1%
Mexico	1.4%	1.5%	1.4%	1.5%	1.4%	1.4%
Russia	5.7%	5.6%	6.1%	6.1%	5.7%	5.7%
Saudi Arabia	1.6%	1.4%	1.4%	1.3%	1.6%	1.6%
South Africa	1.4%	1.4%	1.4%	1.3%	1.4%	1.4%
South Korea	1.7%	1.8%	1.8%	1.8%	1.7%	1.7%
Turkey	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
United Kingdom	1.7%	1.7%	1.6%	1.7%	1.7%	1.7%
United States	18.6%	18.4%	17.7%	18.8%	18.6%	18.6%

TABLE C9. GHG inc LULUCF | Cumulative 1850–2024 (colonial attribution)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**3609.37**	**3175.09**	**1.678**
World (country-attributable) ($GtCO_2e$)	**3608.25**	**3175.09**	**1.678**
By institutional group			
Annex I	55.1%	56.0%	46.4%
Annex II	41.2%	43.6%	34.3%
Annex II + other EU Members	43.9%	46.5%	36.9%
Non-Annex I	44.9%	44.0%	53.6%
OECD	47.1%	49.9%	40.3%
EU	13.5%	14.4%	10.5%
BRICS	32.2%	32.5%	31.0%
G7	35.1%	37.4%	29.5%
G20	75.3%	78.0%	69.8%
Non-Annex I G20 members	28.1%	30.2%	31.0%
By income group			
HIC	56.9%	57.3%	47.4%
UMIC	30.8%	32.3%	35.4%
LMIC	9.7%	8.8%	13.5%
LIC	2.6%	1.6%	3.7%
By development group			
LDC	4.0%	2.4%	6.1%
LLDC	2.7%	2.2%	4.5%
SIDS	0.6%	0.3%	0.7%
LIC/LMIC/SIDS/LDC	12.7%	10.7%	17.7%
By region			
Europe and Central Asia	31.5%	31.3%	24.4%
North America	20.6%	21.6%	19.9%
Latin America & Caribbean	10.8%	9.8%	11.5%

(Continued)

TABLE C9. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GMST (°C/%)
East Asia & Pacific	23.4%	25.0%	25.8%
South Asia	4.3%	4.2%	5.4%
Middle East & North Africa	4.3%	4.5%	5.3%
Sub-Saharan Africa	5.2%	3.5%	7.6%
G20 countries			
Argentina	0.9%	0.9%	1.0%
Australia	1.4%	1.4%	1.5%
Brazil	4.8%	4.6%	5.3%
Canada	2.2%	2.0%	2.3%
China	12.7%	15.1%	13.0%
France	2.3%	2.4%	1.3%
Germany	3.3%	3.8%	2.9%
India	3.8%	3.8%	4.8%
Indonesia	2.4%	2.0%	3.3%
Italy	1.0%	1.1%	0.9%
Japan	2.3%	2.5%	2.1%
Mexico	1.2%	1.5%	1.3%
Russia	10.0%	8.1%	7.0%
Saudi Arabia	0.7%	0.6%	0.8%
South Africa	0.9%	1.0%	1.0%
South Korea	0.7%	0.8%	0.7%
Turkey	0.7%	0.9%	0.7%
United Kingdom	5.7%	6.1%	2.4%
United States	18.3%	19.6%	17.7%

TABLE C10. GHG exc LULUCF | Cumulative 1850–2024 (colonial attribution)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**2205.73**	**2735.70**	**1.051**
World (country-attributable) ($GtCO_2e$)	**2204.54**	**2735.70**	**1.051**
By institutional group			
Annex I	61.2%	59.5%	55.9%
Annex II	46.9%	45.4%	42.8%
Annex II + other EU Members	50.5%	48.7%	46.3%
Non-Annex I	38.8%	40.5%	44.1%
OECD	53.3%	51.5%	49.3%
EU	15.9%	15.4%	14.4%
BRICS	30.9%	31.7%	29.8%
G7	41.5%	39.6%	37.8%
G20	79.2%	78.2%	75.2%
Non-Annex I G20 members	26.5%	27.2%	28.5%

(Continued)

TABLE C10. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GMST (°C/%)
By income group			
HIC	64.1%	61.6%	58.0%
UMIC	27.9%	28.6%	32.1%
LMIC	7.1%	8.0%	8.6%
LIC	0.9%	1.8%	1.2%
By development group			
LDC	1.0%	2.2%	1.5%
LLDC	1.3%	2.0%	2.4%
SIDS	0.5%	0.5%	0.6%
LIC/LMIC/SIDS/LDC	8.5%	10.3%	10.4%
By region			
Europe and Central Asia	32.9%	33.3%	29.8%
North America	24.7%	22.9%	23.7%
Latin America & Caribbean	4.8%	6.2%	5.2%
East Asia & Pacific	24.8%	24.6%	26.2%
South Asia	3.8%	4.3%	4.2%
Middle East & North Africa	6.0%	5.2%	7.1%
Sub-Saharan Africa	2.9%	3.4%	3.9%
G20 countries			
Argentina	0.5%	0.8%	0.5%
Australia	1.1%	1.2%	1.2%
Brazil	1.2%	2.0%	1.5%
Canada	2.0%	1.8%	2.0%
China	15.5%	15.3%	16.2%
France	2.3%	2.5%	1.9%
Germany	4.8%	4.3%	4.4%
India	3.6%	3.9%	3.9%
Indonesia	1.1%	1.1%	1.6%
Italy	1.3%	1.3%	1.3%
Japan	3.4%	3.0%	3.1%
Mexico	1.2%	1.3%	1.3%
Russia	9.3%	9.4%	6.9%
Saudi Arabia	1.1%	0.7%	1.2%
South Africa	1.2%	1.1%	1.3%
South Korea	1.0%	1.0%	1.0%
Turkey	0.7%	0.8%	0.8%
United Kingdom	4.9%	5.5%	3.4%
United States	22.8%	21.2%	21.7%

TABLE C11. CO_2 inc LULUCF | Cumulative 1850–2024 (colonial attribution)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GCP BLUE	GCP OSCAR	GCP LUCE	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**2902.72**	**2249.25**	**2902.72**	**2619.87**	**2727.37**	**1.216**
World (country-attributable) ($GtCO_2e$)	**2856.84**	**2249.25**	**2856.36**	**2573.51**	**2681.01**	**1.216**
By institutional group						
Annex I	56.8%	57.6%	56.8%	56.5%	58.7%	52.3%
Annex II	42.6%	45.4%	42.6%	43.3%	43.6%	39.1%
Annex II + other EU Members	45.1%	48.5%	45.1%	45.9%	46.2%	42.0%
Non-Annex I	43.2%	42.4%	43.2%	43.5%	41.3%	47.7%
OECD	48.5%	52.1%	48.5%	49.3%	49.4%	45.3%
EU	13.3%	15.1%	13.3%	13.5%	14.0%	11.8%
BRICS	32.3%	32.6%	32.3%	31.8%	32.5%	30.1%
G7	36.5%	39.3%	36.6%	37.6%	37.5%	34.4%
G20	76.7%	80.1%	76.7%	77.3%	77.6%	73.2%
Non-Annex I G20 members	27.8%	30.8%	27.8%	28.4%	27.1%	29.0%
By income group						
HIC	58.6%	59.2%	58.6%	58.8%	60.7%	53.2%
UMIC	30.8%	32.5%	30.8%	31.5%	30.0%	33.9%
LMIC	8.3%	7.6%	8.3%	7.7%	7.2%	10.1%
LIC	2.3%	0.6%	2.3%	2.0%	2.1%	2.7%
By development group						
LDC	3.5%	1.1%	3.5%	3.0%	3.0%	4.5%
LLDC	2.3%	1.4%	2.3%	2.4%	2.0%	3.5%
SIDS	0.6%	0.2%	0.6%	0.5%	0.5%	0.7%
LIC/LMIC/SIDS/LDC	11.1%	8.4%	11.1%	10.1%	9.7%	13.4%
By region						
Europe and Central Asia	31.2%	30.8%	31.2%	30.2%	32.2%	27.2%
North America	22.4%	23.3%	22.4%	23.1%	23.4%	22.8%
Latin America & Caribbean	10.7%	9.3%	10.7%	11.7%	10.0%	10.9%
East Asia & Pacific	23.9%	26.2%	23.9%	24.2%	23.8%	25.9%
South Asia	3.4%	3.8%	3.4%	3.1%	3.1%	3.8%
Middle East & North Africa	3.5%	4.3%	3.5%	3.6%	3.6%	3.7%
Sub-Saharan Africa	4.9%	2.3%	4.9%	4.0%	4.0%	5.7%
G20 countries						
Argentina	0.8%	0.6%	0.8%	0.7%	0.7%	0.8%
Australia	1.1%	1.3%	1.1%	1.2%	1.0%	1.2%
Brazil	4.9%	4.6%	4.9%	5.6%	4.7%	5.0%
Canada	2.6%	2.2%	2.6%	2.2%	2.6%	2.5%
China	12.9%	15.7%	12.9%	12.8%	12.8%	12.7%
France	2.1%	2.1%	2.1%	2.0%	2.1%	1.4%
Germany	3.3%	4.4%	3.3%	3.8%	3.6%	3.5%
India	3.0%	3.5%	3.0%	2.9%	2.8%	3.4%
Indonesia	2.5%	2.1%	2.5%	2.7%	2.6%	3.4%

(Continued)

TABLE C11. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GCP BLUE	GCP OSCAR	GCP LUCE	GMST (°C/%)
Italy	0.9%	1.2%	0.9%	1.0%	1.0%	1.0%
Japan	2.7%	3.1%	2.7%	2.9%	2.7%	2.7%
Mexico	1.3%	1.5%	1.3%	1.2%	1.1%	1.2%
Russia	10.5%	7.8%	10.5%	9.6%	11.3%	7.9%
Saudi Arabia	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
South Africa	1.0%	1.1%	1.0%	1.0%	0.9%	1.0%
South Korea	0.7%	0.9%	0.7%	0.8%	0.8%	0.8%
Turkey	0.7%	0.9%	0.7%	0.5%	0.6%	0.6%
United Kingdom	5.2%	5.2%	5.2%	4.8%	4.7%	2.9%
United States	19.8%	21.1%	19.8%	20.8%	20.8%	20.3%

TABLE C12. CO_2 exc LULUCF | Cumulative 1850–2024 (colonial attribution)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GCP fossil	GMST (°C/%)
World (all emissions) ($GtCO_2e$)	**1844.55**	**1862.25**	**1844.55**	**0.810**
World (country-attributable) ($GtCO_2e$)	**1798.67**	**1862.25**	**1798.19**	**0.810**
By institutional group				
Annex I	63.3%	63.5%	63.3%	62.1%
Annex II	49.0%	48.9%	49.0%	48.6%
Annex II + other EU Members	52.6%	52.4%	52.6%	52.5%
Non-Annex I	36.7%	36.5%	36.7%	37.9%
OECD	55.4%	55.3%	55.5%	55.4%
EU	16.5%	16.7%	16.5%	16.7%
BRICS	31.0%	31.4%	31.0%	28.6%
G7	43.5%	43.2%	43.5%	43.2%
G20	81.2%	81.1%	81.2%	78.6%
Non-Annex I G20 members	26.6%	26.5%	26.6%	26.7%
By income group				
HIC	66.1%	66.1%	66.1%	63.7%
UMIC	27.1%	27.0%	27.1%	29.1%
LMIC	6.2%	6.1%	6.2%	6.5%
LIC	0.6%	0.7%	0.6%	0.6%
By development group				
LDC	0.5%	0.5%	0.5%	0.5%
LLDC	1.1%	1.1%	1.1%	2.0%
SIDS	0.5%	0.4%	0.5%	0.5%
LIC/LMIC/SIDS/LDC	7.2%	7.2%	7.2%	7.6%
By region				
Europe and Central Asia	33.2%	33.6%	33.2%	32.8%
North America	26.2%	25.9%	26.2%	26.2%
Latin America & Caribbean	4.3%	4.2%	4.3%	4.3%

(Continued)

TABLE C12. (Continued)

Group/Country	OWID (GCB 2025)	PRIMAP-hist v2.7	GCP fossil	GMST (°C/%)
East Asia & Pacific	25.6%	25.6%	25.6%	25.7%
South Asia	3.7%	3.7%	3.7%	3.8%
Middle East & North Africa	5.1%	5.0%	5.1%	5.1%
Sub-Saharan Africa	1.9%	1.9%	1.9%	2.0%
G20 countries				
Argentina	0.5%	0.5%	0.5%	0.5%
Australia	1.1%	1.1%	1.1%	1.1%
Brazil	1.0%	1.0%	1.0%	1.0%
Canada	2.0%	1.9%	2.0%	2.0%
China	15.9%	15.9%	15.9%	15.9%
France	2.2%	2.2%	2.2%	2.2%
Germany	5.3%	5.3%	5.3%	5.3%
India	3.6%	3.5%	3.6%	3.7%
Indonesia	0.9%	0.9%	0.9%	1.0%
Italy	1.4%	1.5%	1.4%	1.4%
Japan	3.9%	3.8%	3.9%	3.9%
Mexico	1.2%	1.3%	1.2%	1.2%
Russia	9.3%	9.7%	9.3%	6.8%
Saudi Arabia	1.1%	0.9%	1.1%	1.1%
South Africa	1.3%	1.3%	1.3%	1.3%
South Korea	1.2%	1.2%	1.2%	1.2%
Turkey	0.7%	0.7%	0.7%	0.7%
United Kingdom	4.5%	4.4%	4.5%	4.2%
United States	24.2%	24.0%	24.2%	24.2%

Data

All data used for this analysis are available here.

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