THE ENERGY AND RESOURCES INSTITUTE

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Emissions and Consumption

An Approach to Climate Justice

Research
The Energy and Resources Institute (TERI), 2024

Publication Title
Emissions and Consumption: An Approach to Climate Justice

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Acknowledgements
We thank Dr. Prodipto Ghosh for his advice. We also thank Abhas Mukherjee for publication support, Mannu Mahto for the cover design, and Aman Sachdeva for printing support. We acknowledge John Andruse and Ravi Nair for their administrative support.

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List of Acronyms

AU	African Union
CBEs	Consumption-Based Emissions
CO_2	Carbon Dioxide
EU	European Union
EU-27	European Union with 27 member countries
G20	Group of Twenty
GCB	Global Carbon Budget
GCP	Global Carbon Project
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GNI	Gross National Income
HDI	Human Development Index
IPCC	Intergovernmental Panel on Climate Change
MoEFCC	Ministry of Environment, Forest and Climate Change
MWh	Megawatt-hour
NDCs	Nationally Determined Contributions
OECD	Organisation for Economic Co-operation and Development
PBEs	Production-Based Emissions
SDGs	Sustainable Development Goals
TCRE	Transient Climate Response to Cumulative CO_2 Emissions
UNDESA	United Nations Department of Economic and Social Affairs
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

The climate crisis is intensifying, with global surface temperatures having increased by approximately 1.1°C above pre-industrial levels, primarily due to human activities (IPCC, 2023). This trajectory poses significant risks, including extreme weather events, sea-level rise, and biodiversity loss. To stabilise the climate and adhere to the Paris Agreement's goal of limiting the increase in global average temperature to well below 2°C above pre-industrial levels, while pursuing efforts to cap the temperature increase at 1.5°C, urgent action is required to halt greenhouse gas (GHG) emissions globally. To limit global warming to 1.5°C with an 85% likelihood, only 300 $GtCO_2$ of the carbon budget remains (IPCC, 2021).

The growing crisis requires urgent action to arrest the trend of global emissions, bearing in mind the need to ensure climate justice. Climate justice is achieved when actions are taken to reduce global emissions based on the principle of equity and common but differentiated responsibilities and respective capabilities (CBDR-RC) of countries. This approach also aims to minimize the disproportionate impacts of climate change on marginalized communities, ensure that developing countries' ability to meet their rising energy needs is not compromised, and secure communities' access to affordable energy sources.

The paper discusses ways of ensuring climate justice by linking emissions to patterns of consumption of energy in the developed and developing countries and analysing the global trend of production- and consumption-based emissions. The analysis is based on data reported by the Global Carbon Budget project and Our World in Data.

Developed countries have consistently overconsumed while transferring significant emissions to developing countries. In 1990, developed countries produced 11,845 million tonnes of CO_2 and consumed 12,597 million tonnes, resulting in a net import of 752 million tonnes. By 2021, their consumption remained high at 12,542 million tonnes, while production decreased to 10,902 million tonnes, leading to a larger trade-off of 1,640 million tonnes.

With around 2 tonnes per capita, India has the lowest per capita emissions among G20 countries. In developing and low-income countries, consumption-based per capita emissions are lower than production-based per capita emissions.

With about 18% of the world's population, India accounts for only 3.4% of cumulative emissions. In contrast, with about 7% of the world's population, the EU collectively contributed 17% of historical emissions (295,970 million tonnes). The United States, with about 4% of the world's population, is the largest cumulative emitter, contributing 24% of global emissions historically (426,915 million tonnes).

For developing countries, the Human Development Index (HDI) and energy consumption have a high correlation coefficient. CO_2 per capita and primary energy per capita are also highly correlated. This correlation has decreased in developed countries. Significant divergence is evident between the apparent efforts at emissions reduction in developed countries and their per capita energy consumption. Developed or high-income countries are characterized by high and unsustainable energy consumption patterns.

Promoting sustainable consumption in developed countries, addressing underconsumption of energy in developing countries, and ensuring equitable energy access are essential for climate justice. Climate justice is achievable if consumption across the globe is rationalised through the adoption of global standards for equitable and sustainable energy consumption. The '2000-

Watt Society' is a concept advocating for energy use per person to 2000 watts (approximately 48 kWh per day) while maintaining a high quality of life. One tonne of CO_2 per person per year equates to a demand of about 500 watts of non-renewable energy. The concept assumes that, in the long term, 2000 watts—aligned with the Paris Agreement—will consist of 75% (1500 watts) renewable energy-based consumption (2WS, 2024). While the concept is currently applied at the community and city level, its alignment with the Paris Agreement and the absence of other benchmarks make it a relevant metric for energy consumption.

A comparative analysis of primary energy consumption across various G20 countries and groupings reveals disparities in consumption against the 2,000-watt target. The United States consumes 8,781 watts per person, while India consumes 865 watts per person. Significant disparities exist between country groupings, with low-income countries consuming 140 watts, lower-middle-income countries consuming 692 watts, upper-middle-income countries consuming 3,418 watts, and high-income countries consuming 6,023 watts, compared to the 2,000-watt target for sustainability.

In the global context of climate change, both underconsumption and overconsumption of energy need to play a role in shaping the discourse on climate justice. As there is divergence between per capita emissions and per capita consumption, a more nuanced framework for global climate actions is required—one that reflects not only the historical responsibility for emissions but also current levels of consumption and socio-economic development. By incorporating consumption-based emissions, HDI, and per capita energy use into global climate negotiations, the international community can better target climate policies.

While the Intergovernmental Panel on Climate Change (IPCC) guidelines offer a robust framework for estimating emissions, they predominantly emphasize production-based accounting. A key shortcoming is the lack of granularity in commonly employed Tier 1 methodologies, which may fail to accurately capture the complexities of lifestyle-related emissions. Although Tier 2 and Tier 3 methodologies can provide deeper insights, these more refined approaches are not widely adopted due to resource limitations.

Tripling energy efficiency and renewable energy targets must be complemented by reducing unsustainable energy consumption, particularly in high-income countries. Establishing time-bound consumption reduction targets ensures alignment with global sustainability goals and supports achieving a high HDI without exceeding ecological limits.

The fight against climate change and the pursuit of climate justice are deeply intertwined with issues of consumption and inequality. High-income countries must acknowledge and take responsibility for their historically high levels of emissions and overconsumption, which have driven global warming. At the same time, developing countries must be given the tools and support to grow sustainably. By fostering global cooperation and accountability, and by adopting a comprehensive classification system that considers consumption, emissions, and development indicators, the world can move towards a more just and sustainable future.

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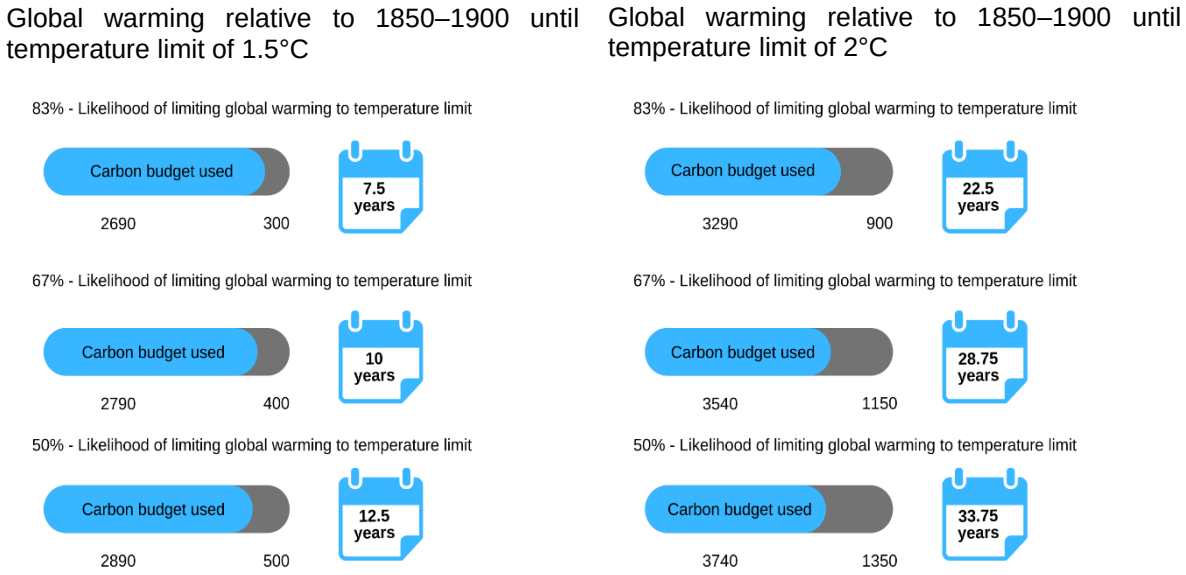
1. Global Climate Change: A Consequence of Unsustainable Consumption

The climate crisis is intensifying, with global surface temperatures having increased by approximately 1.1°C above pre-industrial levels, primarily due to human activities (IPCC, 2023). This trajectory poses significant risks, including extreme weather events, sea-level rise, and biodiversity loss. To stabilise the climate and adhere to the Paris Agreement's goal of limiting the increase in global average temperature to well below 2°C above pre-industrial levels, while pursuing efforts to cap the temperature increase at 1.5°C, urgent action is required to halt greenhouse gas (GHG) emissions globally. To limit global warming to 1.5°C with an 85% likelihood, only a carbon budget of 300 $GtCO_2$ remains (IPCC, 2021). Figure 1 illustrates the estimated remaining carbon budgets according to different likelihoods for various temperature limit scenarios from the beginning of 2020, expressed in gigatonnes of CO_2 ($GtCO_2$), assuming annual emissions of 40 Gt per year.

Figure 1: Estimated remaining carbon budgets and approximate time from the beginning of 2020 ($GtCO_2$)



Source: Based on IPCC (2021)

The urgency of climate action has driven the climate discourse towards a focus on the growth of current emissions in emerging and developing countries, resulting in an oversight of the underlying causes of the climate crisis. Both historical and current consumption serve as the driving forces behind the continued rise in the global trajectory of emissions and are incompatible with the climate stabilization goal.

According to the IPCC's Sixth Assessment Report, historical cumulative net CO_2 emissions are calculated to be 2400 ± 240 $GtCO_2$ for the period from 1850 to 2019, with 58% occurring between 1850 and 1989, and 42% between 1990 and 2019 (IPCC, 2022). The industrialized countries, as designated under the UNFCCC, the Paris Agreement, and the Kyoto Protocol, are responsible for 68% of global historical GHG emissions during 1850 and 2019, despite constituting only 19% of the global population (Friedlingstein et al., 2023). India, on the other hand, is responsible for about 4% of global cumulative emissions during this period, while accounting for 17.8% of the global population as of 2019 (Friedlingstein et al., 2023).
Most reported data fail to account for the emissions that have occurred due to colonial exploitation and resource extraction within a specific territory/region. Most mainstream data

sources calculating cumulative emissions for post-colonial European countries like the UK, France, Portugal, Spain, and the Netherlands exclude the vast overseas emissions generated during their colonial rule. This omission conceals the true scale of their environmental impact, masking the significant climate debt owed to former colonies where emissions were outsourced on a large scale (Evans, 2021).

The United Nations Framework Convention on Climate Change (UNFCCC), established in 1992, underscores the historical responsibility of developed countries for GHG emissions and reaffirms the equity principle of common but differentiated responsibilities (UN, 1992). The Kyoto Protocol, 1997, operationalized the UNFCCC, mandating industrialized countries to reduce GHG emissions, with an emphasis on their historical responsibility for current emission levels (UNFCCC, 2024). This led to the development of Nationally Determined Contributions (NDCs) in Article 3 of the Paris Agreement (UNFCCC, 2015), a bottom-up approach where countries voluntarily set climate action targets.

Significant divergence is noticed between efforts seemingly made at emissions reduction in developed countries vis-à-vis their per capita energy consumption, characterized by high and unsustainable levels of energy consumption patterns in more developed, high-income countries. The paper attempts to present the relevant data relating to consumption-based emissions and analyse the implications of energy consumption for sustainability and equity in the growth process across the globe.

To this end, the link between consumption and climate justice is explored. Climate justice implies taking actions to reduce global emissions based on the principle of equity and common but differentiated responsibilities and respective capabilities (CBDR-RC) of countries, while ensuring that the disproportionate impacts of climate change on marginalized communities are minimized, the ability of developing countries to meet their rising energy needs is not compromised, and communities' access to affordable energy sources remains secure.

Promoting sustainable consumption in developed countries, addressing the underconsumption of energy in developing countries, and ensuring equitable energy access are essential for climate justice. Climate justice is achievable if energy consumption across the globe is rationalised through the adoption of global standards of equitable and sustainable energy consumption. The '2000-Watt Society' is a concept that advocates for energy use per person to be 2000 watts (approximately 48 kWh per day) while maintaining a high quality of life. One tonne of CO_2 per person per year equates to a demand of about 500 watts of non-renewable energy. The concept assumes that, in the long term, 2000 watts—aligned with the Paris Agreement—will consist of 75% (1500 watts) renewable energy-based consumption (2WS, 2024). While the concept is currently applied at the community and city levels, its alignment with the Paris Agreement and the absence of other benchmarks makes it a relevant metric for energy consumption.

The paper advocates using the '2000-Watt Society' as a benchmark to evaluate overconsumption and underconsumption of energy. An initial global equality in terms of energy consumption at 2000 watts per person can be attempted, with gradual upward adjustments aligning with sustainable development goals for all. Achieving this will require a substantial overhaul of energy consumption patterns, particularly in developed countries.

2. Trends in Emissions

There are different types of emissions based on the distinction between production and consumption. Production-based emissions (PBEs) are calculated within a country's territorial boundaries, reflecting the emissions generated during the production of goods and services, including those destined for export. In contrast, consumption-based emissions (CBEs) adjust for trade by accounting for emissions embedded in imported goods while subtracting emissions from exports, offering a broader perspective on the environmental impact of consumption patterns. Finally, trade-based emissions highlight the net emissions associated with the trade of goods, indicating whether a country is a net importer or exporter of emissions. Box 1 depicts the various types of emissions.

Box 1: Types of emissions based on production and consumption

Production-based emissions (PBEs): These emissions are usually measured based on what is produced within a country's boundaries, without accounting for the goods that are traded globally. This method, known as production-based or territorial emissions, is used for reporting emissions and setting domestic and international climate targets (Global Carbon Project, 2023). If a country's territorial emissions are decreasing, but its consumption-based emissions are rising, it may indicate that the country is offshoring its emissions to other regions. Authorities typically report carbon emissions using PBEs and territorial emissions, which account for emissions linked to the production and consumption of goods and services within a region, whether for domestic use or export. PBEs, at the global level, also encompass emissions from international activities, such as international aviation and shipping, as well as emissions from non-resident activities, which are not included in territorial emissions (IPCC, 2022).

Consumption-based emissions (CBEs): These account for national or regional emissions adjusted for trade. They are calculated based on domestic emissions by taking a country's production-based emissions, subtracting the emissions from goods and services exported, and adding the emissions from goods and services imported (Global Carbon Project, 2023). CBEs attributes to the emissions based on where goods and services are consumed, not where they are produced. It provides insight into the consumption patterns and lifestyle choices of a country's residents.

Trade-based emissions: Trade-based emissions refer to the net emissions associated with goods that are imported or exported within an economy (GCB, 2023). A positive value indicates that a country or region is a net importer of emissions, while a negative value signifies that it is a net exporter. In addition to the commonly reported territorial emissions (or production-based emissions), statisticians also compute consumption-based emissions, which are adjusted for trade. The difference between PBE and CBE is denoted as transfer-based emissions in this paper.

Production-based emissions, however, do not paint the entire picture. To address the causes of emissions and understand how consumption choices and supply chains contribute, it is essential to consider CBEs (IPCC, 2022). This approach highlights the need to look beyond territorial emissions to prevent pollution outsourcing and achieve global decarbonization. CBEs provide

insights into a country's trade balance, household consumption patterns, and the carbon footprint of cities, often extending beyond their boundaries.

Table 1 illustrates production, consumption, and transfer-based emissions for key countries.

Table 1: Production, consumption and transfer-based emissions for key entities (million tonnes)

Entity	1990			2000			2010			2021		
	Prod	Cons	Tfr.	Prod	Cons	Tfr.	Prod	Cons	Tfr.	Prod	Cons	Tfr.
Developed economies	11845	12597	-752	12922	14239	-1317	12523	14235	-1712	10902	12542	-1640
Developing economies	6352	6000	352	9531	8367	1164	17137	15196	1941	22397	20480	1917
Economies in transition	3994	2961	1033	2246	1413	833	2539	1880	659	2585	1880	705
OECD	12159	13027	-868	13556	14958	-1402	13353	15162	-1809	11925	13594	-1668
High-income countries	12409	13295	-886	13925	15224	-1299	14015	15784	-1768	12659	14413	-1754
Upper-middle-income countries	7497	6499	997	8068	6714	1354	14197	12163	2033	17451	15420	2031
Lower-middle-income countries	2108	1748	361	2559	2064	495	3820	3335	485	5601	4998	603
Low-income countries	189	15	174	164	18	147	194	29	164	197	71	126
Developed	15366	15259	107	14880	15572	-692	14670	15999	-1329	13027	14244	-1217
Developing	6713	6124	590	9610	8167	1443	17278	15020	2258	22583	20359	2223
United States	5121	5048	73	6010	6254	-244	5680	5966	-286	5032	5572	-540
Russia	2536	2042	494	1479	996	483	1633	1362	271	1712	1360	352
Japan	1157	1317	-160	1264	1549	-285	1215	1448	-233	1062	1225	-163
Germany	1055	1195	-140	899	1084	-185	831	1022	-191	679	831	-152
South Korea	251	321	-70	440	485	-45	594	651	-56	616	689	-73
Canada	459	483	-25	567	581	-14	556	607	-51	537	502	35
Australia	278	243	35	350	291	59	406	395	11	387	338	48
Italy	439	567	-128	471	574	-103	437	604	-168	337	433	-96
United Kingdom	602	670	-68	569	744	-175	512	677	-165	347	513	-166
France	393	493	-100	407	519	-113	377	503	-127	307	416	-109
China	2485	2320	165	3649	3263	387	8621	7337	1284	11336	10320	1016
India	578	575	3	978	908	69	1677	1578	100	2674	2448	226
Indonesia	155	147	8	281	240	41	446	445	0	616	624	-8
Saudi Arabia	208	193	16	302	206	96	525	518	7	631	622	9
Mexico	317	321	-4	392	440	-48	457	495	-39	469	506	-37
Brazil	219	245	-27	340	350	-10	440	485	-45	497	462	35
Turkey	152	215	-64	230	255	-25	316	354	-38	453	422	31
South Africa	313	219	94	378	286	92	463	337	126	426	298	128
Argentina	112	113	-1	143	141	1	186	172	14	190	177	13
EU-27	3870	4402	-532	3602	4214	-613	3431	4300	-868	2806	3498	-692
AU	658	583	76	930	733	197	1215	1096	119	1435	1389	46
World	22753	22753	0	25501	25501	0	33306	33306	0	36817	36817	0

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

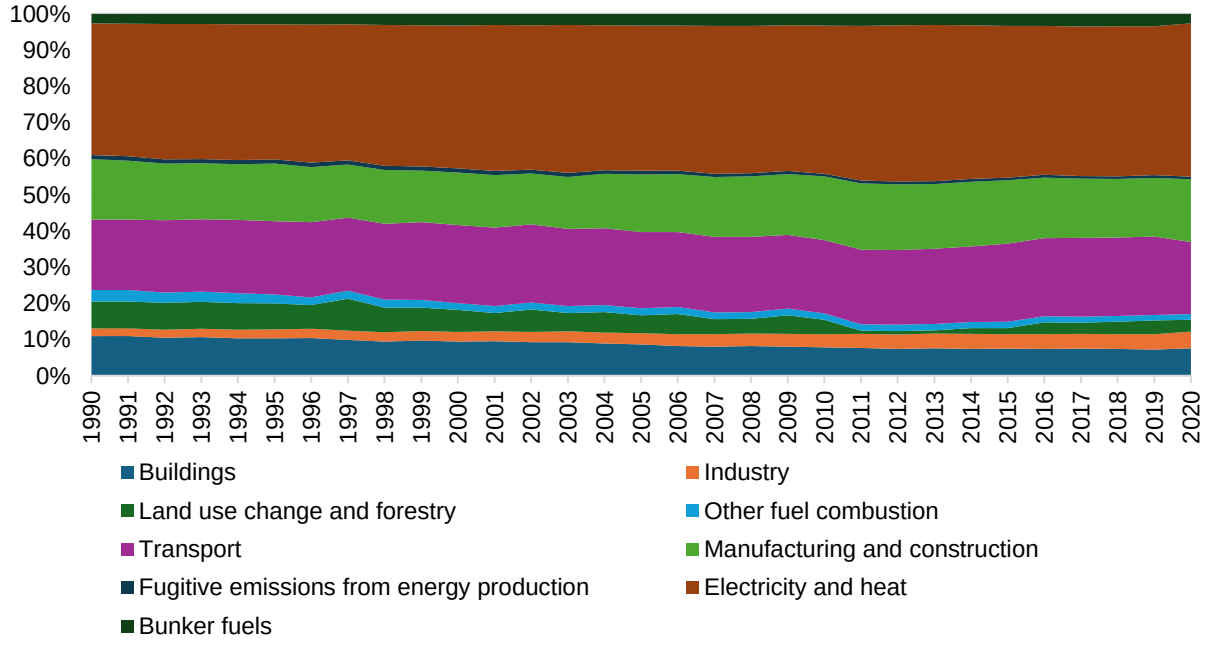
Developed countries have consistently over-consumed while transferring significant emissions to developing countries. In 1990, developed countries produced 11,845 million tonnes of CO_2 and consumed 12,597 million tonnes, resulting in a net import of 752 million tonnes. By 2021,

their consumption remained high at 12,542 million tonnes, while production decreased to 10,902 million tonnes, leading to a larger trade-off of 1,640 million tonnes.

Conversely, developing countries show an increase in production-based emissions. Production rose from 6,352 million tonnes in 1990 to 22,397 million tonnes in 2021, and consumption increased from 6,000 to 20,480 million tonnes. The positive transfer (1,917 million tonnes in 2021) indicates that these countries, particularly industrial hubs, are net exporters of emissions through trade and offshoring to developed countries. For example, China's production-based emissions increased from 2,485 million tonnes in 1990 to 11,336 million tonnes in 2021, with a net export of 1,016 million tonnes. China's transfer emissions are greater than the emissions of Germany, South Korea, Canada, Australia, Italy, the United Kingdom, and France. Developed countries, including the US and the European Union, show negative transfers. In 2021, the US consumed 5,572 million tonnes of CO_2 while producing 5,032 million tonnes, resulting in a negative transfer of 540 million tonnes. The European Union had a negative transfer of 692 million tonnes. Similarly, Japan, Germany, and the UK exhibit growing negative transfers, reflecting their reliance on carbon-intensive imports from developing countries.

Figure 2 displays production-based CO_2 emissions across various sectors globally from 1990 to 2020, including buildings, industry, land-use change and forestry, other fuel combustion, transport, manufacturing, fugitive emissions from energy production, electricity and heat, and bunker fuels.

Figure 2: CO_2 emissions share by sector, world



Source: Climate Watch (2023) and Our World in Data (2024)

Global CO_2 emissions have grown across most sectors between 1990 and 2020. Emissions from electricity and heat production rose by 75.5%, from 8.61 to 15.11 billion tonnes, reflecting the rising global energy demand. Transport emissions increased by 53.9%, from 4.61 to 7.09 billion tonnes, driven by expanding transportation infrastructure. Manufacturing and construction saw a 56.6% increase, reaching 6.18 billion tonnes. Industrial emissions grew by

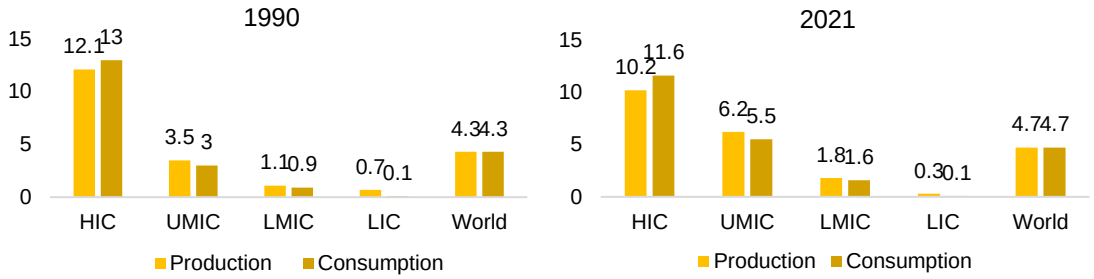
approximately 230%, indicating significant industrial expansion. Meanwhile, emissions from buildings remained relatively stable, growing by just 4.2%. Land-use change and forestry experienced a 33.9% decline, peaking in 2013 but dropping to 1.17 billion tonnes in 2020, driven by improved land management practices. Other fuel combustion decreased by 24.7%, while fugitive emissions remained stable.

Annexure 1 presents global CO_2 emissions from 1990 to 2022 across various economic groupings and regions. Annexure 2 highlights G20 countries' production-based emissions. Annexure 3 presents the consumption-based CO_2 emissions for various regions. Annexure 4 provides detailed data on G20 countries' production-based emissions. Annexure 5 provides detailed time-series data on emissions embedded in trade for various economic groupings, while Annexure 6 provides the data for G20 countries.

3. Per Capita Emissions

Figure 3 depicts the disparities in per capita production- and consumption-based emissions across different income groups of countries for 1990 and 2021. There is an increase in the difference between production-based and consumption-based per capita emissions for high-income countries, where CBEs are higher than PBEs. In the case of developing and low-income countries, consumption-based per capita emissions are lower than production-based per capita emissions.

Figure 3: Production-based and consumption-based per capita emissions



HIC: High-income countries
UMIC: Upper-middle-income countries
LMIC: Lower-middle-income countries
LIC: Low-income countries

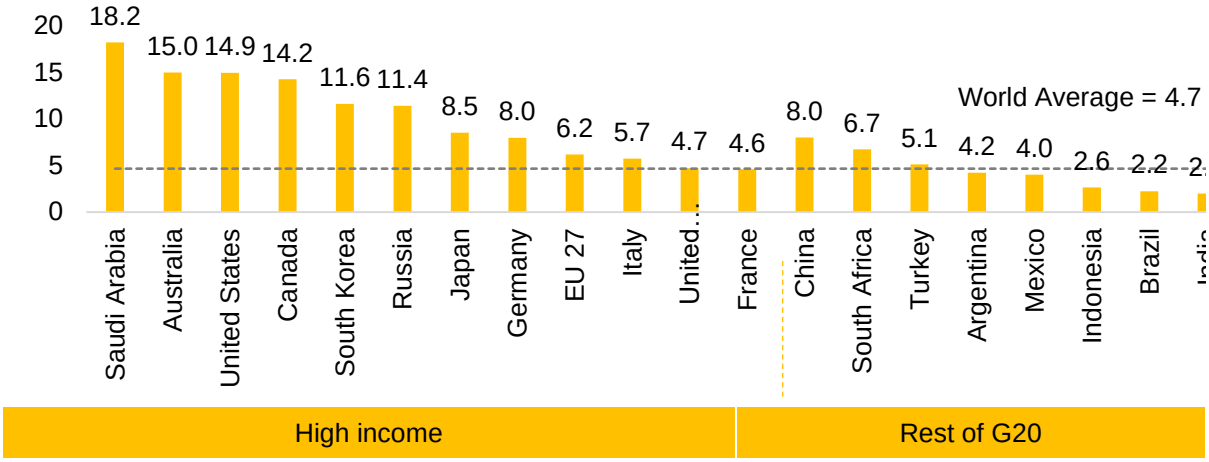
Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

More detailed data is provided in Annexures 7, 8, 9, and 10. The data in Annexure 7 highlights the disparity in per capita CO_2 emissions between developed and developing countries. In 1990, developed economies recorded high per capita emissions of 10.3 tonnes, reducing to 7.0 tonnes by 2022—a 32% decline. However, this reduction still leaves developed countries with emissions significantly above the global average, indicating ongoing overconsumption. North America and Oceania exemplify this, with 2022 figures of 10.5 and 9.9 tonnes, respectively. In contrast, developing economies have seen a rise in per capita emissions, from 2.6 tonnes in 1990 to 3.5 tonnes in 2022. Asia, particularly, has experienced a 124% increase. Income disparities further reveal that high-income countries had a modest 17% decrease, while upper-middle-income countries saw a 79% rise due to industrialization and carbon outsourcing.

Figure 4 shows per capita emissions for G20 countries. The United States has per capita emissions of nearly 15 tonnes in 2022, which is more than three times the world average. With

2 tonnes per capita, India has the lowest per capita emissions among G20 countries. Annexure 8 shows G20 data over time.

Figure 4: Per capita CO_2 emissions of G20 countries (tonnes), 2022

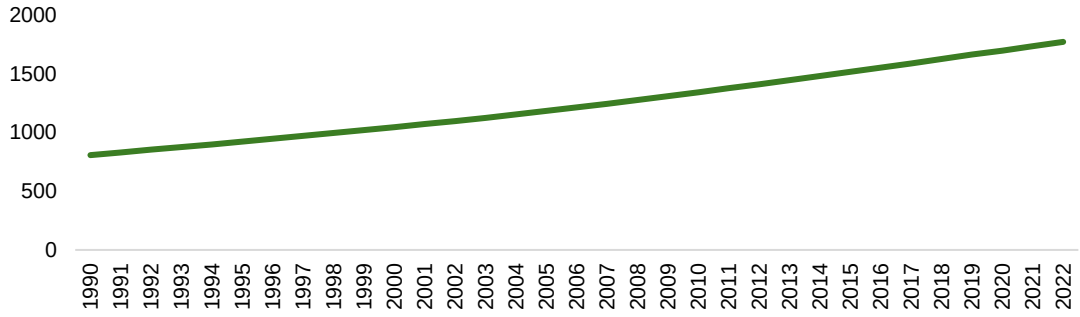


Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

4. Cumulative Emissions and Carbon Budget

The Preamble to the UNFCCC acknowledges that developed countries have historically contributed the largest share of global GHG emissions. However, ongoing efforts seek to shift the focus away from historical responsibility towards developing regions projected to contribute a larger share of future emissions, driven by development needs and priorities such as poverty eradication (TERI, 2021). The cumulative CO_2 emissions in 1990 were around 808 billion tonnes (Figure 5). This marks the beginning of a steady climb in emissions, which corresponds with the period of globalization, rapid industrialization in developing countries, and continued reliance on fossil fuels by developed countries.

Figure 5: Cumulative CO_2 emissions, world (billion tonnes)



Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

By 2000, cumulative emissions crossed 1,000 billion tonnes, reflecting a significant 200 billion tonne increase in just 10 years. By 2010, cumulative emissions reached 1,300 billion tonnes. This decade saw the expansion of coal-based energy in developing countries, as well as the failure of the Kyoto Protocol to bring about meaningful reductions in emissions from major emitters. By 2022, emissions rose to approximately 1,773 billion tonnes, showing a near doubling of total emissions since 1990. Despite global climate agreements like the Kyoto Protocol (1997) and the Paris Agreement (2015), the above graph shows that no decrease in global emissions has taken place since 1990. The consistent annual increase in emissions

suggests that, on average, global emissions are adding about 30–40 billion tonnes of CO_2 per year to the cumulative total.

From 1850 to 2019, a total of 2390 (± 240) $GtCO_2$ of anthropogenic CO_2 was emitted. The remaining carbon budgets as of January 1, 2020, for limiting global warming to 1.5°C, 1.7°C, and 2.0°C are 500 $GtCO_2$, 850 $GtCO_2$, and 1,350 $GtCO_2$, respectively, based on the 50th percentile of the Transient Climate Response to Cumulative CO_2 Emissions (TCRE) (IPCC WG I AR6, 2023). More than four-fifths of the global carbon budget for limiting warming to 1.5°C (with a >50% probability) and about two-thirds of the budget for keeping it under 2°C (with a >67% probability) have already been used up (IPCC, 2022).

Annex-I countries, which represent roughly 19% of the global population, are responsible for more than half of the historical GHG emissions (MoEFCC, 2023). In contrast, India, despite accounting for 17.8% of the global population, has contributed only 4% to cumulative global emissions between 1850 and 2019 (ibid).

The early occupation of the ‘carbon space’ by the developed world has significantly limited the flexibility of developing countries. As a result, developing countries will be compelled to adopt low-carbon development pathways that are conceptually unclear, ill-understood, and initially cost-intensive in the short and medium term (Kanitkar et al., 2009). It is important to note, as stated in Article 4, paragraph 7 of the UNFCCC, that poverty eradication and sustainable development remain top priorities for developing countries. However, the near depletion of the global carbon budget, leaving only a small portion for the world's population, creates an added burden for developing countries, particularly large economies like India.

Achieving equitable distribution of carbon space requires the ‘convergence’ of currently unequal per capita emissions. Understanding what constitutes a good quality of life and how resources are allocated globally is crucial for understanding sustainable lifestyles. The emerging discourse on sustainable consumption highlights the need for a comprehensive and holistic approach towards consumer lifestyles. It is crucial to consider the social dimensions of production and consumption patterns in lifestyles.

Developed economies are responsible for 950,801 million tonnes of CO_2 emissions, accounting for 54% of the global total cumulative emissions. In contrast, developing economies contributed 587,060 million tonnes (33%), while economies in transition emitted 189,697 million tonnes (11%). Between 1990 and 2022, developed economies’ share decreased slightly to 41% of emissions (403,327 million tonnes), while developing economies’ share increased to 47% (468,085 million tonnes). This reflects the industrial growth in developing countries since 1990, particularly in Asia. Annex-I countries (which include developed countries and some economies in transition) contributed 1,098,392 million tonnes of emissions (62%), vastly overshadowing the 618,008 million tonnes from Non-Annex I countries (35%).

Table 2 shows the cumulative CO_2 emissions of key groupings and regions. Between 1990 and 2022, Annex I countries' emissions accounted for 47% of the world total, while Non-Annex I countries' emissions were 49% of the total during this period. If the period is extended back from 1750 to 2022, OECD or Annex I countries are seen to have emitted 978,971 million tonnes, representing 55% of the global total. From 1990 to 2022, they contributed 427,639 million tonnes (43%). High-income countries accounted for 57% of historical emissions (1750–2022) and 45% from 1990 to 2022. Upper-middle-income countries (e.g., China, Brazil) emitted 553,308 million tonnes (31%) historically, and 391,196 million tonnes (40%) from

1990 to 2022, reflecting their rapid industrial growth, especially in Asia and Latin America. Lower-middle-income countries and low-income countries together contributed a very small portion of emissions, 9% and 1%, respectively, over both periods.

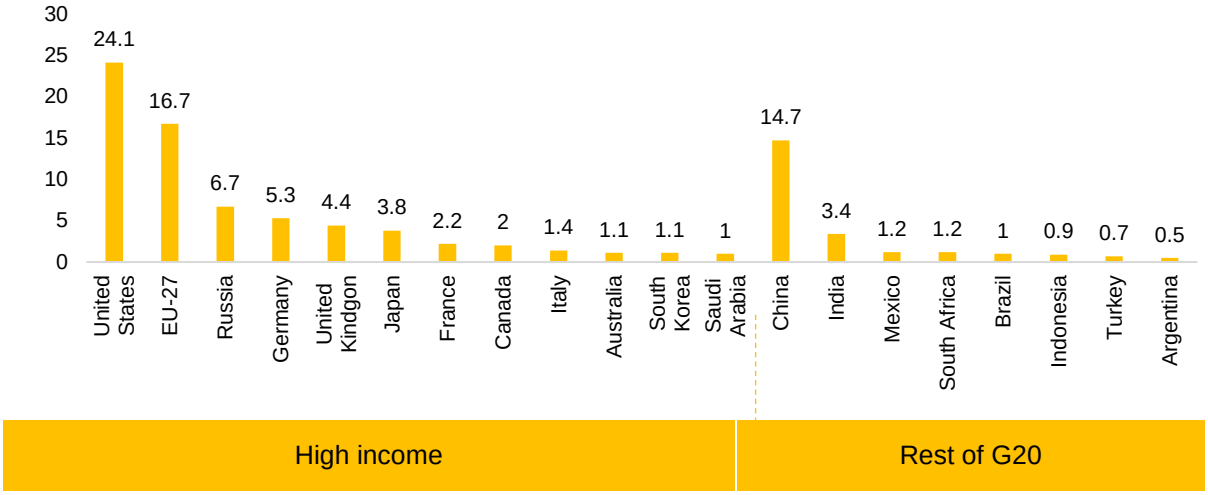
Table 2: Cumulative CO_2 emissions of key groupings and regions

Entity	1750–2022		1990–2022	
	million tonnes	%	million tonnes	%
Developed economies	950,801	54	403,327	41
Developing economies	587,060	33	468,085	47
Economies in transition	189,697	11	85,758	9
Annex I	1,098,392	62	464,467	47
Non-Annex I	618,008	35	483,737	49
OECD	978,971	55	427,639	43
High-income countries	1,001,743	57	445,170	45
Upper-middle-income countries	553,308	31	391,196	40
Lower-middle-income countries	163,675	9	115,745	12
Low-income countries	10,183	1	5753	1
Developed	1,114,917	63	476,381	48
Developing	604,277	34	473,563	48
Africa	51,012	3	35,747	4
Asia	578,425	33	454,823	46
Europe	542,460	31	203,914	21
North America	490,241	28	219,619	22
Oceania	21,733	1	13,555	1
South America	45,061	3	30,218	3
World	**1,772,868**	**100**	**987,750**	**100**

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Figure 6 shows the cumulative CO_2 emissions of the G20 countries for the period 1750–2022.

Figure 6: Cumulative CO_2 emissions for G20 countries and EU-27 (billion tonnes), 1750–2022 (% of world total)



Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

The figure shows cumulative CO_2 emissions as a percentage of the world total for G20 countries and the EU-27 from 1750 to 2022. The United States accounts for 24.1% of global emissions, followed by the EU-27 at 16.7%. For the EU, this number does not account for colonial emissions.

Table 3 shows the cumulative CO_2 emissions of the G20 countries for the periods 1750–2022 (historical) and 1990–2022.

Table 3: Cumulative CO_2 emissions of G20

Entity	1750–2022		1990–2022	
	million tonnes	%	million tonnes	%
United States	426,915	24	182,821	19
Russia	119,291	7	55,316	6
Germany	93,986	5	28,246	3
United Kingdom	78,835	4	16,725	2
Japan	67,735	4	40,079	4
France	39,398	2	12,328	1
Canada	34,613	2	17,905	2
Italy	25,416	1	13,983	1
South Korea	19,529	1	16,660	2
Australia	19,285	1	12,094	1
China	260,619	15	219,699	22
India	59,741	3	49,313	5
South Africa	21,860	1	13,552	1
Mexico	21,119	1	14,111	1
Saudi Arabia	17,596	1	14,615	1
Brazil	17,177	1	12,743	1
Indonesia	15,712	1	12,963	1
Turkey	11,787	1	9533	1
Argentina	8815	0	5255	1
European Union (27)	295,970	17	113,063	11
Africa	51,012	3	35,747	4
World	1,772,868	100	987,750	100

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

The US is the largest emitter in both periods, contributing 24% of global emissions historically (426,915 million tonnes) and 19% from 1990–2022 (182,821 million tonnes). The EU collectively contributed 17% of historical emissions (295,970 million tonnes) but reduced its share to 11% from 1990–2022 (113,063 million tonnes).

China is the second-largest emitter, with 15% of global emissions historically (260,619 million tonnes), rising to 22% (219,699 million tonnes) post-1990, reflecting its rapid industrialization. Germany, the United Kingdom, Japan, and Canada collectively contributed 15% of historical emissions but reduced their share to 10% post-1990. Australia and South Korea also show significant contributions, largely driven by carbon-heavy industries like mining and manufacturing. India accounts for only 3.4% of the cumulative emissions.

5. The Carbon Equation: Energy, Emissions, and Development

The Human Development Index (HDI) is a composite measure that evaluates achievements in three key dimensions of human development: health, education, and standard of living. It is calculated as the geometric mean of normalized indices for each dimension (UNDP, 2024). The health dimension is measured by life expectancy at birth, while the education dimension is assessed through the average years of schooling for adults aged 25 years and above, along with the expected years of schooling for children of school age. The standard of living is measured by gross national income (GNI) per capita. HDI uses the logarithm of income to account for the decreasing significance of income as GNI increases. The scores for the three HDI dimensions are then aggregated into a composite index using the geometric mean. The HDI was developed to highlight that the capabilities and well-being of people, rather than solely economic growth, should be the primary criteria for evaluating a country's development.

For developing countries, HDI and energy consumption have a high correlation coefficient (Table 4). HDI is a composite measure that evaluates a country's average achievements in three basic aspects of human development: health (life expectancy), education (years of schooling), and standard of living (GNI per capita). Energy consumption, particularly electricity, plays a crucial role in enhancing these dimensions. Research shows a strong link between HDI and electricity consumption. A study of 60 countries found HDI rises with consumption, especially around 4,000 kWh per person annually, correlating to an HDI of 0.9 (Global Energy Futures and Human Development, n.d.). Beyond this point, benefits plateau.

Table 4 depicts a consolidated table with correlation coefficients of key development and emissions variables for the top 10 CO_2-emitting countries in developed and developing categories.

Table 4: Correlation coefficients between key development indicators and CO_2 emissions for top 10 emitters

	Developed				Developing			
	1990	2000	2010	2020	1990	2000	2010	2020
Primary energy per capita and HDI	0.65	0.51	0.32	0.24	0.75	0.72	0.70	0.75
CO_2 per capita and HDI	0.57	0.57	0.35	0.21	0.73	0.67	0.63	0.70
CO_2 per capita and primary energy per capita	0.88	0.88	0.84	0.85	0.98	0.98	0.98	0.97
CO_2 emissions and GDP	0.82	0.92	0.95	0.95	0.56	0.81	0.95	0.99
CO_2 emissions per capita and GDP per capita	0.22	0.44	0.49	0.37	0.91	0.72	0.73	0.80

Source: Based on Global Carbon Budget (2023), Our World in Data (2024), World Bank (2024), and UNDP (2023)

Primary energy consumption refers to the energy available from natural resources, such as the fuels used in power plants, before any transformation occurs. This includes coal prior to combustion, uranium, or crude oil. Primary energy encompasses the energy required by end users in the forms of electricity, transportation, and heating, as well as the inefficiencies and energy losses that occur when raw resources are converted into usable forms (Energy Institute - Statistical Review of World Energy, 2024). It is measured in kilowatt-hours per person. Researchers employ the substitution method to adjust primary energy consumption for efficiency losses associated with fossil fuels. This method seeks to align non-fossil energy

sources with the inputs that would be required if the energy were generated from fossil fuels, assuming that the inefficiencies of wind and solar electricity are comparable to those of coal or gas.

Per capita emissions indicate the average emissions produced by an individual in a specific country or region, calculated by dividing the total emissions by the population (GCP, 2023). GDP per capita is calculated by dividing the gross domestic product (GDP) by the midyear population. It represents the total value added by all resident producers within the economy, along with any product taxes, minus subsidies that are not included in the product value. This calculation does not account for the depreciation of manufactured assets or the depletion and degradation of natural resources as per the World Bank. The data is in current US dollars.

GDP at purchaser's prices is the total gross value added by all resident producers in the economy, along with any product taxes, minus subsidies that are not factored into the product value. It is calculated without deducting for the depreciation of manufactured assets or the depletion and degradation of natural resources. The data is presented in current US dollars.

From 1990 to 2020, there have been significant shifts in terms of energy carbon emissions, consumption patterns, and economic growth. These shifts between developed and developing countries reveal critical trends that highlight the interplay between energy usage, carbon emissions, and human development.

In developed countries, the correlation coefficient between primary energy consumption per capita and HDI declined over the period from 1990 to 2020. It was positive and strong (0.65) in 1990, gradually decreased to 0.51 in 2000, 0.32 in 2010, and became very weak (0.24) in 2020. This indicates that, over time, human development has decoupled from energy consumption. However, in developing countries, the correlation between these variables has been stable—strong in 1990 (0.75), reducing to 0.72 and 0.70 in 2000 and 2010, respectively. However, it again increased to 0.75 in 2020.

The correlation of HDI with emissions per capita in developed countries was similarly weak (0.57) in 1990 and 2000, gradually declining to 0.35 in 2010 and 0.21 in 2020. In developing countries, there has been fluctuation in the correlation between CO_2 per capita and HDI—it was positive and strong (0.73) in 1990, became less strong (0.73) in 2000, but increased to 0.70 in 2020.

In 1990, the correlation coefficient (r) of emissions with GDP in developed countries was positive and strong (0.82) and increased in 2000 (0.92) and 2010 (0.95). In 2020, the correlation remained constant at 0.95. Similarly, in developing countries, the correlation between CO_2 emissions and GDP was moderate (0.56) in 1990. Over the years, the relation became positive and strong—0.81 in 2000, 0.95 in 2010, and 0.99 in 2020. This suggests that economic growth has been dependent on carbon emissions. The sharp increase in the relation between CO_2 emissions and GDP in developing countries underscores that economic growth remains largely driven by high-carbon industries.

Between 2015 and 2018, a total of 67 countries, or 58%, including China and India, relatively decoupled their GDP from consumption-based emissions, indicating that emissions grew at a slower rate than GDP (IPCC, 2022). The USA also showed relative decoupling of both consumption-based emissions and production-based emissions during this period, having achieved a strong decoupling of economic growth from emissions between 2005 and 2015

(ibid). However, this decoupling can be temporary, as emissions may rise again after a period of decoupling.

The correlation coefficient between CO_2 emissions per capita and GDP per capita in developed countries has been weak throughout the period. In 1990, it was 0.22, then increased to 0.44 and 0.49 in 2000 and 2010, respectively, before further decreasing to 0.37 in 2020. In contrast, in developing countries, the relationship between CO_2 emissions and GDP per capita was positive and strong (0.91) in 1990, reduced to 0.72 in 2000, and again increased to 0.8 in 2020.

6. 2000-Watt Lifeline Energy Consumption and Implications for Climate Justice and Equity

The '2000-Watt Society' is a concept designed to address sustainable and equitable energy consumption (Bretschger et al., 2010; Imboden, 2000; Saran & Sharan, 2015; UNU, 2009; Zulliger, 1999). The concept gained prominence due to the rising global population, increasing energy demand, and the linkages to emissions, which have highlighted the need for sustainable energy solutions. It advocates limiting energy use per person per year to 2000 watts (approximately 48 kWh per day) while maintaining a high quality of life. Box 2 briefly describes the concept of the 2000-Watt Society, which envisions a sustainable and equitable world where each person consumes no more than 2000 watts of continuous power. This target serves as a global benchmark for sustainable energy consumption. The concept can act as a reference point for energy consumption levels.

This framework is built on three core principles: efficiency, sufficiency, and consistency. Efficiency focuses on using technological advancements to achieve the same level of comfort and functionality with less energy. Sufficiency promotes the idea that individuals should consume only what is necessary, recognizing that beyond a certain point, additional consumption does not improve well-being. Consistency advocates for the transition to renewable energy sources and sustainable practices in energy production.

Box 2: 2000-Watt Society

The 2000-Watt Society represents a sustainable and socially just society. For every person on Earth, 2000 watts of continuous power (primary energy) are available. This is sufficient to ensure prosperity and a high quality of life.

Source: https://www.2000watt.swiss/english.html

Figure 7 provides a comparative analysis of primary energy consumption across various countries and groupings of the G20 against the 2000-watt target.

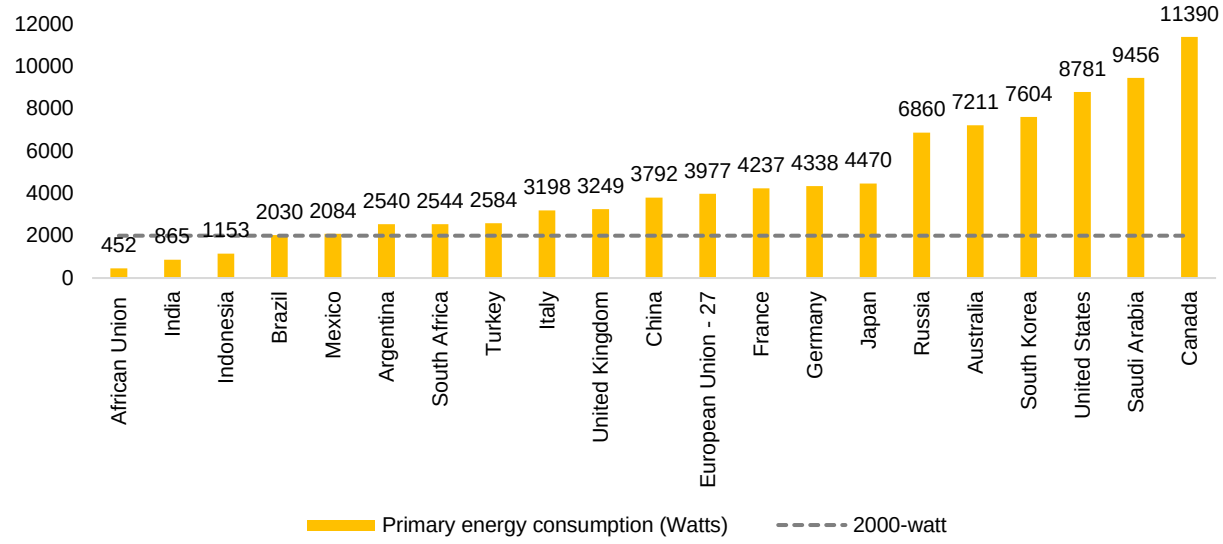
The African Union consumes only 452 watts per person, and India 865 watts. This reflects their relatively lower energy use compared to developed countries and highlights the challenge of ensuring equitable access to energy for economic development and poverty alleviation in these regions.

Indonesia and Brazil are closer to the 2000-watt goal, consuming 1153 watts and 2030 watts per person, respectively. Although Brazil slightly exceeds the target, both countries are in the process of rapid economic development, and their energy consumption is expected to rise

further as their economies grow. Similarly, Mexico consumes 2084 watts, slightly above the target, indicating a similar stage of energy use and economic growth as Brazil.

Countries such as Argentina, South Africa, and Turkey, with energy consumption levels between 2540 and 2584 watts, and Italy and the United Kingdom, consuming 3198 watts and 3249 watts, respectively, are in a more industrialized category but remain far above the 2000-watt target. These countries have more established economies and higher standards of living, which contribute to their increased energy demands. However, their levels of energy consumption, while moderate, highlight the ongoing challenge of balancing economic development with sustainable energy use.

Figure 7: Per capita primary energy consumption in 2023 for G20 countries and groupings (Watts)



Source: Based on Energy Information Administration (2023)

Moving into the higher consumption category, China consumes 3,792 watts per person, and the European Union (27) averages 3,977 watts, indicating energy consumption levels that reflect their vast industrial and manufacturing sectors. France (4,237 watts), Germany (4,338 watts), and Japan (4,470 watts) also fall into this category, consuming more than double the 2,000-watt target. These economies are highly developed and energy-intensive, making it more difficult for them to reduce consumption while maintaining economic growth. Their challenge lies in implementing efficiency measures and transitioning to renewable energy sources.

At the top of the list, the United States consumes 8,781 watts per person, while Saudi Arabia reaches 9,456 watts, both reflecting extremely high energy consumption. In the case of Saudi Arabia, the energy-intensive nature of its oil industry is likely a major factor, while the US demonstrates a high standard of living and industrial activity contributing to its energy use. Canada, with a staggering 11,390 watts per person, consumes the most energy in the dataset, largely due to its vast natural resource extraction industries and cold climate, which drive up energy use for heating.

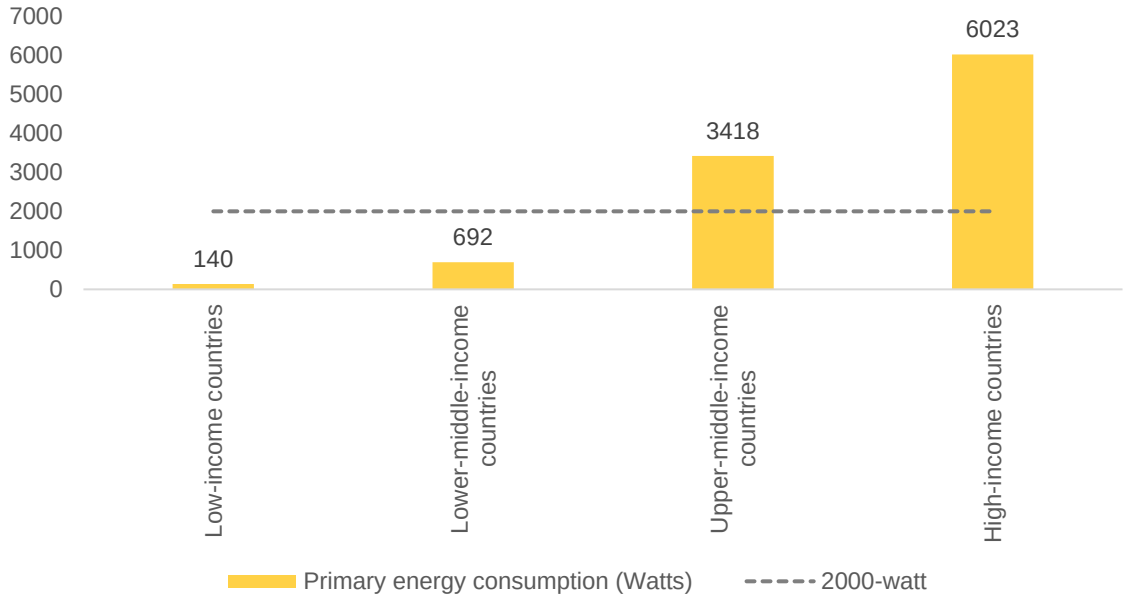
In summary, the trends illustrates the wide disparity in energy consumption globally. On the higher end of the spectrum, Russia, consuming 6,860 watts, along with Australia (7,211 watts) and South Korea (7,604 watts), reflects highly industrialized countries with significant energy

demands, particularly in energy-intensive industries. These countries have an even larger gap to close if they aim to meet the 2,000-watt target.

While regions like AU and India fall well below the 2,000-watt target, more developed countries, such as the United States, Canada, and Saudi Arabia, exceed it by significant margins. This highlights the need for differentiated global energy policies that account for varying levels of industrialization, energy access, and development. The countries consuming the most energy will need to make substantial changes in their infrastructure, industrial processes, and lifestyle choices to move closer to sustainable consumption levels in line with the 2,000-watt Society's goals. For countries below the target, the challenge lies in increasing energy access and consumption without compromising sustainability.

Figure 8 depicts the stark differences in primary energy consumption across countries classified by World Bank income levels: low-income, lower-middle-income, upper-middle-income, and high-income. The comparison is made in relation to the 2,000-watt target.

Figure 8: Per capita primary energy consumption in 2023 for income groupings (Watts)



Source: Based on Energy Information Administration (2023)

Starting with low-income countries, the graph shows that these countries have an average primary energy consumption of just 140 watts per person, far below the 2000-watt target. While this minimal energy usage might seem aligned with sustainability goals, it is more indicative of severe energy poverty. These countries likely lack the infrastructure and economic resources to provide widespread access to modern energy, which in turn hampers opportunities for economic development and improved quality of life. The challenge for low-income countries is to increase energy consumption in a way that lifts living standards without overreliance on unsustainable energy sources.

In lower-middle-income countries, energy consumption rises to 692 watts per person, still significantly under the 2000-watt target. These countries are in a developmental phase where economic growth is beginning to require more energy, but overall consumption remains relatively low. While they are advancing beyond the challenges faced by low-income countries,

they must find a way to continue their growth trajectory while balancing the need for sustainable energy use and development.

Moving to upper-middle-income countries, the graph highlights a substantial increase in energy consumption, with these countries averaging 3418 watts per person—well above the 2000-watt benchmark. This energy usage reflects the higher levels of industrialization and improved living standards in these countries. However, it also underscores the need for these countries to address their growing environmental impact by adopting more energy-efficient technologies and transitioning to renewable energy sources to reduce their overconsumption.

Finally, high-income countries stand out with the highest levels of energy consumption, averaging 6023 watts per person, far exceeding the 2000-watt target. These countries, which are highly industrialised and enjoy the benefits of advanced infrastructure and a high quality of life, consume over 43 times more energy than low-income countries. Their consumption levels pose a significant challenge to global sustainability efforts, as meeting the 2000-watt target will require them to undertake extensive reforms in energy use. This could involve transitioning to clean energy, enhancing energy efficiency, and promoting changes in lifestyle and consumption patterns to lower overall energy demand.

In summary, the graph underscores the global inequality in energy consumption, with high-income countries using far more energy than low- and middle-income countries. This disparity highlights the need for tailored approaches to energy policy, where developing countries need to focus on expanding energy access, while high-income countries need to drastically reduce their energy consumption to achieve global sustainability goals. The path forward requires balancing energy equity with sustainability, as countries at different stages of development face unique challenges in their energy transitions.

The 2000-Watt Society can serve as a benchmark for sustainable consumption by promoting reduced energy use while maintaining a high quality of life. The 2000-Watt Society concept faces several challenges, including obstacles related to lifestyle changes by individuals (Morosini, 2010). Another significant challenge is infrastructure limitations, such as inefficient industrial systems and inadequate public transport (Scarinci et al., 2017). Despite these hurdles, the 2000-Watt Society remains a vital framework for future energy consumption, aligning with global efforts to reduce environmental impacts and promote sustainability. Its principles of efficiency, sufficiency, and consistency provide a comprehensive approach to reducing energy use. Furthermore, considering the high correlation between energy consumption and development indicators, the 2000-watt target could serve as an indicator linked to climate justice.

7. Conclusions and Recommendations

Implications for India

India's status in global CO_2 emissions highlights the complex relationship between the historical and current emissions of developed and developing countries and their common but differentiated responsibilities and respective capabilities for addressing climate change. With per capita CO_2 emissions of 2 tonnes per annum, India ranks 112th globally, far below many developed countries (Annexure 11). Furthermore, India's per capita energy consumption of 7 MWh remains significantly lower than the global average of 21 MWh, and even more so when compared to the 46 MWh consumed in developed countries, also known as Annex-I countries. India's overall contribution to global cumulative emissions remains modest, accounting for only 3.37% of cumulative global emissions in 2022 (Global Carbon Budget, 2023). This is in

stark contrast to the 24% contributed by the United States and the 78.6% by developed countries combined (ibid.).

Moreover, the complexity of India's position is further magnified when examining consumption-based emissions, which include trade. When trade-based emissions are considered, the disparities between developed and developing countries increase. Developed countries have managed to stabilize or peak their emissions by outsourcing carbon-intensive production to developing countries, further complicating the global narrative of emission responsibility.

For India, the challenge lies in maintaining economic growth while simultaneously addressing its carbon emissions. As a developing country with low energy consumption, India faces the difficult task of ensuring climate justice in a carbon-constrained world, requiring support from the global community in the form of green finance, technology transfer, and capacity building.

Underconsumption and Overconsumption and Linkages with Climate Justice

In the global context of climate change, underconsumption and overconsumption of energy play a critical role in shaping the discourse on climate justice. Underconsumption refers to the reality in many developing countries, including India, where limited access to energy and essential resources constrains social and economic development. With 7 MWh per capita energy consumption, India exemplifies the challenges faced by developing countries suffering from energy poverty, preventing them from fully industrializing and improving living standards.

In contrast, overconsumption characterizes developed countries, where high standards of living are sustained through disproportionate levels of resource and energy use. Developed countries, having built their wealth on decades of high-energy consumption-driven growth, continue to consume energy at unsustainable levels, driving global climate change. This overconsumption has led to environmental degradation that disproportionately affects the world's poorest communities, those who have contributed the least to the problem. Thus, the unequal distribution of energy consumption underpins the issue of climate justice—the notion that the costs and benefits of climate action should be shared equitably across countries and populations.

Addressing both overconsumption and underconsumption of energy is crucial to achieving climate justice. High-energy-consuming countries must reduce their consumption to more sustainable levels, while low-energy-consuming countries should be empowered to increase their consumption in a way that raises living standards but relies on low-carbon energy sources. This balancing act requires international cooperation, with the developed world taking responsibility for its historical emissions and supporting developing countries in their quest for sustainable growth.

Need for a Benchmarks and Frameworks on Overconsumption and Underconsumption

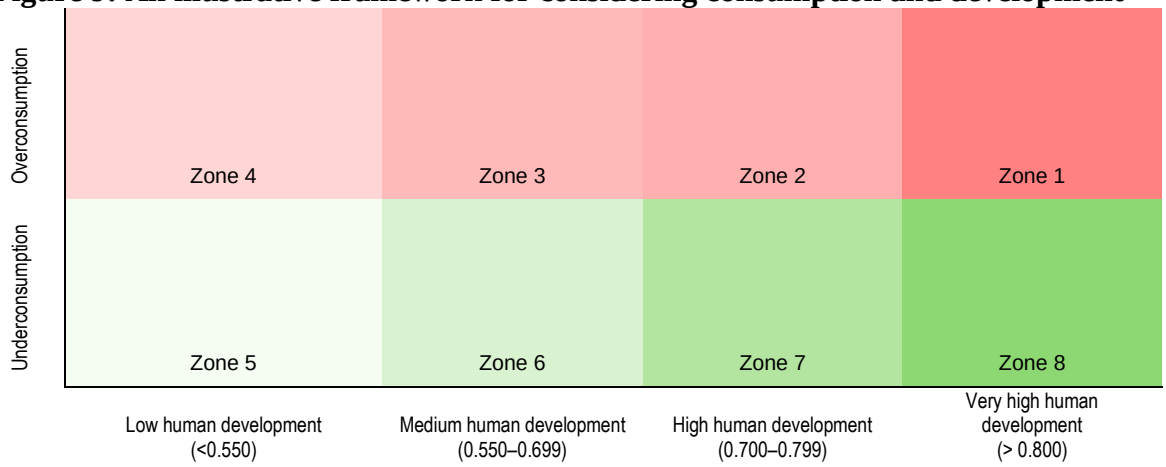
There is a divergence between aggregate emissions and consumption per capita. A more nuanced framework is required—one that reflects not only historical responsibility for emissions but also current levels of consumption and socio-economic development. By incorporating consumption-based emissions, HDI, and per capita energy use into global climate negotiations, the international community can better target climate policies. This approach would ensure that countries with higher levels of overconsumption take greater responsibility for reducing their environmental footprint, while countries suffering from underconsumption

receive the support necessary to develop sustainably. Figure 9 depicts an illustrative framework for considering consumption based on historical responsibility and human development.

Over time, developed countries should aim to transition from Zone 1 to sustainable levels of consumption, while developing countries need to progress from Zone 5 to sustainable levels of consumption and a high Human Development Index. This latter transition must be equitable and supported by means of implementation, such as finance, technology, and capacity building. There is an urgent need to develop indicators with benchmarks for the Y-axis. In the long term, the 2000-watt target could serve as a benchmark for per capita energy consumption. Similarly, benchmarks should be developed for historical emissions and other consumption-related indicators.

Benchmarks on fair consumption are also needed. For instance, developed countries that exceed the 2000-watt target, a benchmark for sustainable per capita energy use, should commit to reducing their energy consumption. These countries should also contribute financially and technologically to assist developing countries in achieving low-carbon pathways to development. By doing so, global efforts to mitigate climate change can be fairly distributed, with high-income countries shouldering the burden of reducing emissions, while developing countries focus on improving their living standards through sustainable energy systems.

Figure 9: An illustrative framework for considering consumption and development



While the Intergovernmental Panel on Climate Change (IPCC) guidelines offer a robust framework for estimating emissions, they predominantly emphasize production-based accounting. This focus can limit the understanding of the total emissions linked to consumption, as it overlooks the emissions embedded in imported goods and services that contribute to a country's carbon footprint. A key shortcoming is the lack of granularity in the commonly employed Tier 1 methodologies, which may fail to accurately capture the complexities of lifestyle-related emissions. Although Tier 2 and Tier 3 methodologies can provide deeper insights, these more refined approaches are not widely adopted due to resource limitations.

Tripling energy efficiency and renewable energy targets must be complemented by reducing unsustainable energy consumption, particularly in high-income countries. Establishing time-bound consumption reduction targets ensures alignment with global sustainability goals and supports achieving a high HDI without exceeding ecological limits. Integrating these recommendations into the global indicator framework for Sustainable Development Goals (SDGs), specifically Goal 7 (affordable and clean energy), is key. Energy efficiency and clean

energy, along with sustainable consumption reduction, are required for equitable and sustainable development.

The fight against climate change and the pursuit of climate justice are deeply interwoven with issues of consumption and inequality. High-income countries must acknowledge and take responsibility for their historically high levels of emissions and overconsumption, which have driven global warming. At the same time, developing countries must be given the tools and support to grow in a sustainable manner. By fostering global cooperation and accountability, and by adopting a comprehensive classification system that considers consumption, emissions, and development indicators, the world can move towards a more just and sustainable future. Only through shared responsibility and equitable action can the world address the dual challenges of overconsumption and underconsumption, ensuring that the burdens of climate change are fairly distributed across all countries.

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Annexures

Annexure 1: Production-based CO_2 emissions for groupings and regions (million tonnes)

Entity	1990	2000	2010	2015	2020	2021	2022	%Change
Developed economies	11,845	12,922	12,523	11,845	10,341	10,902	10,845	-8
Developing economies	6352	9531	17,137	19,913	21,294	22,397	22,757	258
Economies in transition	3994	2246	2539	2514	2488	2585	2474	-38
Annex I	18,967	18,134	17,666	16,610	14,685	15,528	15,294	-19
Non-Annex I	6945	9902	17,658	20,441	21,767	22,842	23,239	235
OECD	12,159	13,556	13,353	12,805	11,293	11,925	11,895	-2
High-income countries	12,409	13,925	14,015	13,607	12,015	12,659	12,614	2
Upper-middle-income countries	7497	8068	14,197	15,862	16,725	17,451	17,617	135
Lower-middle-income countries	2108	2559	3820	4683	5222	5601	5672	169
Low-income countries	189	164	194	150	186	197	197	4
Developed	15,366	14,880	14,670	13,912	12,383	13,027	12,839	-16
Developing	6713	9610	17,278	20,107	21,485	22,583	22,975	242
Africa	658	930	1215	1320	1356	1435	1417	115
Asia	6609	9329	16,497	19,113	20,520	21,439	21,772	229
Europe	8038	6156	6124	5614	5029	5310	5105	-36
North America	5990	7100	6866	6610	5835	6201	6280	5
Oceania	310	390	452	452	447	437	441	43
South America	599	812	1072	1193	961	1086	1085	81
World	22,753	25,501	33,306	35,463	35,008	36,817	37,150	63

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Annexure 2: Production-based CO_2 emissions for G20 (million tonnes)

Entity	1990	2000	2010	2015	2020	2021	2022	%Change
United States	5121	6010	5680	5376	4715	5032	5057	-1
Russia	2536	1479	1633	1639	1633	1712	1652	-35
Japan	1157	1264	1215	1223	1040	1062	1054	-9
Germany	1055	899	831	798	647	679	666	-37
South Korea	251	440	594	634	598	616	601	140
Canada	459	567	556	571	523	537	548	20
Australia	278	350	406	401	397	387	392	41
Italy	439	471	437	362	303	337	338	-23
United Kingdom	602	569	512	422	326	347	319	-47
France	393	407	377	331	282	307	298	-24
China	2485	3649	8621	9867	10,914	11,336	11,397	359
India	578	978	1677	2234	2422	2674	2830	390
Indonesia	155	281	446	539	606	616	729	370
Saudi Arabia	208	302	525	679	611	631	663	218
Mexico	317	392	457	480	442	469	512	61
Brazil	219	340	440	529	445	497	483	121
Turkey	152	230	316	385	413	453	436	187
South Africa	313	378	463	446	435	426	404	29
Argentina	112	143	186	192	167	190	193	72
EU-27	3870	3602	3431	3093	2630	2806	2762	-29
AU	658	930	1215	1320	1356	1435	1417	115
World	22,753	25,501	33,306	35,463	35,008	36,817	37,150	63

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Annexure 3: Consumption-based CO_2 emissions for groupings and regions (million tonnes)

Entity	1990	2000	2010	2015	2020	2021	%Change
Developed economies	12,597	14,239	14,235	13,160	11,731	12,542	-0.4
Developing economies	6000	8367	15,196	18,338	19,579	20,480	241.4
Economies in transition	2961	1413	1880	1849	1877	1880	-36.5
Annex I	19,501	19,484	19,911	18,073	16,291	17,391	-10.8
Non-Annex I	6198	8385	15,328	18,506	19,738	20,620	232.7
OECD	13,027	14,958	15,162	14,245	12,711	13,594	4.4
High-income countries	13,295	15,224	15,784	15,054	13,522	14,413	8.4
Upper-middle-income countries	6499	6714	12,163	14,033	14,941	15,420	137.2
Lower-middle-income countries	1748	2064	3335	4213	4660	4998	186.0
Low-income countries	15	18	29	47	64	71	371.3
Developed	15,259	15,572	15,999	14,814	13,423	14,244	-6.7
Developing	6124	8167	15,020	18,256	19,480	20,359	232.5
Africa	583	733	1096	1333	1319	1389	138.4
Asia	6551	8661	14,913	17,803	19,135	19,914	204.0
Europe	7770	6312	6812	5954	5441	5799	-25.4
North America	5906	7356	7213	6988	6269	6716	13.7
Oceania	270	323	431	420	392	379	40.3
South America	604	752	1079	1182	944	1039	72.0
World	22,753	25,501	33,306	35,463	35,008	36,817	61.8

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Annexure 4: Consumption-based CO_2 emissions for G20 (million tonnes)

Entity	1990	2000	2010	2015	2020	2021	%Change
United States	5048	6254	5966	5790	5187	5572	10
Russia	2042	996	1362	1323	1364	1360	-33
Japan	1317	1549	1448	1360	1188	1225	-7
Germany	1195	1084	1022	893	773	831	-30
South Korea	321	485	651	668	659	689	115
United Kingdom	670	744	677	589	461	513	-23
Canada	483	581	607	541	481	502	4
Italy	567	574	604	454	387	433	-24
France	493	519	503	422	376	416	-16
Australia	243	291	395	382	353	338	39
China	2320	3263	7337	8868	9984	10,320	345
India	575	908	1578	2095	2248	2448	325
Indonesia	147	240	445	546	623	624	325
Saudi Arabia	193	206	518	699	615	622	223
Mexico	321	440	495	539	469	506	58
Brazil	245	350	485	548	428	462	88
Turkey	215	255	354	413	399	422	96
South Africa	219	286	337	335	316	298	36
Argentina	113	141	172	200	158	177	57
EU-27	4402	4214	4300	3599	3209	3498	-21
AU	583	733	1096	1333	1319	1389	138
World	22,753	25,501	33,306	35,463	35,008	36,817	62

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Annexure 5: Annual CO_2 emissions embedded in trade for groupings and regions (million tonnes)

Entity	1990	2000	2010	2015	2020	2021	%Change
Developed economies	790	1362	1716	1319	1393	1644	108
Developing economies	58	-687	-1339	-947	-1046	-1200	-2152
Economies in transition	-771	-598	-410	-421	-353	-439	-43
Annex I	571	1395	2249	1467	1610	1867	227
Non-Annex I	-72	-803	-1475	-1059	-1098	-1235	1622
OECD	905	1447	1813	1443	1422	1672	85
High-income countries	886	1299	1768	1447	1507	1754	98
Upper-middle-income countries	-997	-1354	-2033	-1829	-1785	-2031	104
Lower-middle-income countries	-361	-495	-485	-470	-562	-603	67
Low-income countries	-174	-147	-164	-103	-122	-126	-28
Developed	59	812	1417	984	1126	1302	2097
Developing	-33	-788	-1472	-1034	-1144	-1305	3890
Africa	-76	-197	-119	13	-38	-46	-39
Asia	-57	-668	-1584	-1310	-1385	-1525	2562
Europe	-269	156	688	339	412	488	-282
North America	-83	256	347	378	434	515	-717
Oceania	-39	-67	-21	-32	-55	-58	47
South America	5	-59	7	-11	-17	-47	-1037
World	0	0	0	0	0	0	

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Annexure 6: Annual CO_2 emissions embedded in trade for G20 (million tonnes)

Entity	1990	2000	2010	2015	2020	2021	%Change
United States	-73	244	286	414	472	540	-840
United Kingdom	68	175	165	166	135	166	145
Japan	160	285	233	137	148	163	2
Germany	140	185	191	95	126	152	8
France	100	113	127	91	94	109	9
Italy	128	103	168	92	84	96	-25
South Korea	70	45	56	33	61	73	4
Canada	25	14	51	-29	-42	-35	-242
Australia	-35	-59	-11	-20	-43	-48	39
Russia	-494	-483	-271	-316	-269	-352	-29
Mexico	4	48	39	60	26	37	755
Indonesia	-8	-41	0	7	17	8	-196
Saudi Arabia	-16	-96	-7	21	4	-9	-41
Argentina	1	-1	-14	8	-9	-13	-1579
Turkey	64	25	38	28	-14	-31	-148
Brazil	27	10	45	19	-17	-35	-231
South Africa	-94	-92	-126	-111	-119	-128	36
India	-3	-69	-100	-139	-174	-226	8741
China	-165	-387	-1284	-999	-930	-1016	518
EU-27	532	613	868	506	579	692	30
AU	-76	-197	-119	13	-38	-46	-39
World	0	0	0	0	0	0	

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Annexure 7: Annual production-based per capita CO_2 emissions for groupings and regions (tonnes)

Entity	1990	2000	2010	2015	2020	2021	2022	%Change
Developed economies	10.3	9.4	9.2	8.1	6.9	7.2	7.0	-32
Developing economies	2.6	3.3	3.5	3.5	3.3	3.5	3.5	32
Economies in transition	7.0	4.0	4.9	4.9	4.9	5.0	4.9	-30
Annex I	10.4	9.0	8.8	7.7	6.7	6.9	6.8	-35
Non-Annex I	3.0	3.4	3.6	3.6	3.5	3.6	3.6	19
OECD	9.7	9.1	8.9	7.9	6.7	7.0	6.8	-30
High-income countries	12.1	12.7	11.9	11.2	9.7	10.2	10.1	-17
Upper-middle-income countries	3.5	3.4	5.4	5.8	5.9	6.2	6.2	79
Lower-middle-income countries	1.1	1.1	1.4	1.6	1.7	1.8	1.8	56
Low-income countries	0.7	0.4	0.4	0.3	0.3	0.3	0.3	-57
Developed	9.9	8.6	8.6	7.6	6.7	6.9	6.8	-32
Developing	3.3	3.8	4.0	4.1	3.7	3.8	3.8	17
Africa	1.0	1.1	1.2	1.1	1.0	1.0	1.0	-4
Asia	2.1	2.5	3.9	4.3	4.4	4.6	4.6	124
Europe	11.1	8.5	8.3	7.6	6.7	7.1	6.9	-38
North America	14.4	14.8	12.8	11.7	9.9	10.5	10.5	-27
Oceania	11.7	12.6	12.3	11.3	10.2	9.9	9.9	-16
South America	2.0	2.3	2.7	2.9	2.2	2.5	2.5	23
World	4.3	4.1	4.8	4.8	4.5	4.7	4.7	9

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Annexure 8: Annual production-based per capita CO_2 emissions for G20 (tonnes)

Entity	1990	2000	2010	2015	2020	2021	2022	%Change
Australia	16.3	18.4	18.4	16.9	15.5	14.9	15.0	-8
United States	20.6	21.3	18.3	16.6	14.0	14.9	15.0	-28
Canada	16.6	18.5	16.4	16.0	13.8	14.1	14.2	-14
South Korea	5.7	9.4	12.2	12.4	11.5	11.9	11.6	104
Russia	17.1	10.1	11.4	11.3	11.2	11.8	11.4	-33
Japan	9.4	10.0	9.5	9.6	8.3	8.5	8.5	-9
Germany	13.3	11.0	10.2	9.7	7.8	8.1	8.0	-40
Italy	7.7	8.3	7.3	6.0	5.1	5.7	5.7	-26
United Kingdom	10.5	9.7	8.2	6.5	4.9	5.2	4.7	-55
France	7.0	6.9	6.0	5.2	4.4	4.8	4.6	-34
Saudi Arabia	13.0	14.0	17.8	20.7	17.0	17.6	18.2	40
China	2.2	2.9	6.4	7.1	7.7	8.0	8.0	271
South Africa	7.8	8.1	8.9	8.0	7.4	7.2	6.7	-14
Turkey	2.8	3.6	4.3	4.8	4.9	5.3	5.1	83
Argentina	3.4	3.9	4.5	4.4	3.7	4.2	4.2	23
Mexico	3.9	4.0	4.1	4.0	3.5	3.7	4.0	3
Indonesia	0.9	1.3	1.8	2.1	2.2	2.3	2.6	211
Brazil	1.5	1.9	2.2	2.6	2.1	2.3	2.2	55
India	0.7	0.9	1.4	1.7	1.7	1.9	2.0	201
AU	1.0	1.1	1.2	1.1	1.0	1.0	1.0	-4
EU-27	9.2	8.4	7.8	7.0	5.9	6.3	6.2	-33
World	4.3	4.1	4.8	4.8	4.5	4.7	4.7	9

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Annexure 9: Annual consumption-based per capita CO_2 emissions for groupings and regions (tonnes)

Entity	1990	2000	2010	2015	2020	2021	Change
Developed economies	11.7	11.1	11.2	9.9	8.7	9.3	-20.1
Developing economies	3.8	3.8	4.6	4.9	4.8	4.9	27.7
Economies in transition	6.0	3.1	4.2	4.5	4.5	4.5	-25.1
Annex I	11.4	10.4	10.6	9.4	8.3	8.9	-22.1
Non-Annex I	3.7	3.6	4.4	4.7	4.6	4.7	25.9
OECD	11.0	10.6	10.6	9.4	8.1	8.7	-21.0
High-income countries	13.0	13.9	13.4	12.4	10.9	11.6	-10.7
Upper-middle-income countries	3.0	2.8	4.7	5.2	5.3	5.5	81.2
Lower-middle-income countries	0.9	0.9	1.2	1.5	1.5	1.6	67.1
Low-income countries	0.1	0.0	0.1	0.1	0.1	0.1	98.1
Developed	11.3	10.4	10.7	9.5	8.3	9.0	-20.4
Developing	3.8	3.5	4.3	4.7	4.5	4.6	23.7
Africa	0.9	0.9	1.0	1.1	1.0	1.0	9.2
Asia	2.0	2.3	3.5	4.0	4.1	4.2	107.9
Europe	10.8	8.7	9.2	8.0	7.3	7.8	-27.8
North America	14.2	15.3	13.4	12.3	10.6	11.3	-20.1
Oceania	10.2	10.4	11.7	10.5	9.0	8.6	-15.9
South America	2.0	2.2	2.7	2.9	2.2	2.4	17.7
World	4.3	4.1	4.8	4.8	4.5	4.7	8.8

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Annexure 10: Annual consumption-based per capita CO_2 emissions for G20 (tonnes)

Entity	1990	2000	2010	2015	2020	2021	%Change
United States	20.3	22.1	19.2	17.8	15.4	16.5	-19
South Korea	7.3	10.4	13.3	13.1	12.7	13.3	83
Canada	17.5	18.9	17.9	15.2	12.7	13.2	-25
Australia	14.3	15.3	17.9	16.0	13.8	13.1	-9
Germany	15.1	13.3	12.6	10.9	9.3	10.0	-34
Japan	10.7	12.2	11.3	10.7	9.5	9.8	-8
Russia	13.8	6.8	9.5	9.1	9.4	9.4	-32
United Kingdom	11.7	12.6	10.8	9.0	6.9	7.6	-35
Italy	10.0	10.1	10.1	7.5	6.5	7.3	-27
France	8.7	8.9	8.1	6.6	5.8	6.4	-26
Saudi Arabia	12.0	9.6	17.6	21.4	17.1	17.3	44
China	2.0	2.6	5.4	6.4	7.0	7.2	260
South Africa	5.5	6.1	6.5	6.0	5.4	5.0	-9
Turkey	4.0	4.0	4.8	5.2	4.7	5.0	26
Mexico	3.9	4.5	4.4	4.5	3.7	4.0	2
Argentina	3.5	3.8	4.2	4.6	3.5	3.9	13
Indonesia	0.8	1.1	1.8	2.1	2.3	2.3	183
Brazil	1.6	2.0	2.5	2.7	2.0	2.2	32
India	0.7	0.9	1.3	1.6	1.6	1.7	163
EU-27	10.5	9.9	9.8	8.1	7.2	7.9	-25
AU	0.9	0.9	1.0	1.1	1.0	1.0	9
World	4.3	4.1	4.8	4.8	4.5	4.7	9

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

Annexure 11: CO_2 per capita emissions in 2022

Country	CO_2 Per Capita Emissions (tonnes per person)	Rank
Qatar	37.60	1
United Arab Emirates	25.83	2
Bahrain	25.67	3
Kuwait	25.58	4
Brunei	23.95	5
Trinidad and Tobago	22.42	6
Saudi Arabia	18.20	7
Oman	15.73	8
Australia	14.99	9
United States	14.95	10
Canada	14.25	11
Kazakhstan	13.98	12
Luxembourg	11.62	13
South Korea	11.60	14
Russia	11.42	15
Mongolia	11.15	16
Turkmenistan	11.03	17
Iceland	9.50	18
Czechia	9.34	19
Libya	9.24	20
Singapore	8.91	21
Malaysia	8.58	22
Japan	8.50	23
Poland	8.11	24
China	7.99	25
Germany	7.98	26
Iran	7.80	27
Estonia	7.78	28
Ireland	7.72	29
Belgium	7.69	30
Norway	7.51	31
Netherlands	7.14	32
Austria	6.88	33
Bulgaria	6.80	34
South Africa	6.75	35
Finland	6.53	36
Antigua and Barbuda	6.42	37
New Zealand	6.21	38
Israel	6.21	39
European Union 27	6.17	40
Belarus	6.17	41
Seychelles	6.15	42
Bosnia and Herzegovina	6.10	43
Slovakia	6.05	44
Serbia	6.03	45
Slovenia	6.00	46
Suriname	5.80	47
Greece	5.75	48
Italy	5.73	49
Cyprus	5.62	50
Bahamas	5.17	51
Spain	5.16	52
Turkey	5.11	53
Denmark	4.94	54

Country	CO_2 Per Capita Emissions (tonnes per person)	Rank
Kosovo	4.83	55
United Kingdom	4.72	56
Saint Kitts and Nevis	4.71	57
Andorra	4.62	58
Lithuania	4.61	59
France	4.60	60
Hungary	4.45	61
Barbados	4.38	62
Guyana	4.37	63
Lebanon	4.35	64
Croatia	4.35	65
Chile	4.30	66
Argentina	4.24	67
Nauru	4.17	68
Portugal	4.05	69
Switzerland	4.05	70
Iraq	4.03	71
Mexico	4.02	72
Algeria	3.93	73
Liechtenstein	3.81	74
Thailand	3.78	75
Romania	3.74	76
Azerbaijan	3.68	77
Montenegro	3.66	78
Marshall Islands	3.64	79
North Macedonia	3.63	80
Sweden	3.61	81
Latvia	3.56	82
Ukraine	3.56	83
Vietnam	3.50	84
Uzbekistan	3.48	85
Saint Helena	3.30	86
Mauritius	3.27	87
Maldives	3.25	88
Malta	3.10	89
Laos	3.08	90
Equatorial Guinea	3.03	91
Georgia	2.96	92
Tunisia	2.88	93
French Polynesia	2.85	94
Botswana	2.84	95
Venezuela	2.72	96
Grenada	2.71	97
Panama	2.70	98
Indonesia	2.65	99
Saint Lucia	2.62	100
Gabon	2.39	101
Egypt	2.33	102
Ecuador	2.31	103
Uruguay	2.31	104
Armenia	2.31	105
Saint Vincent and the Grenadines	2.30	106
Jamaica	2.30	107
Brazil	2.25	108
Dominica	2.11	109
Dominican Republic	2.11	110
Jordan	2.03	111

Country	CO_2 Per Capita Emissions (tonnes per person)	Rank
India	2.00	112
North Korea	1.95	113
Colombia	1.92	114
Cuba	1.87	115
Morocco	1.83	116
Belize	1.79	117
Peru	1.79	118
Tonga	1.77	119
Bolivia	1.76	120
Albania	1.74	121
Moldova	1.66	122
Namibia	1.54	123
Costa Rica	1.52	124
Kyrgyzstan	1.43	125
Lesotho	1.36	126
Bhutan	1.35	127
Paraguay	1.33	128
Philippines	1.30	129
Syria	1.25	130
Congo	1.25	131
El Salvador	1.22	132
Cambodia	1.19	133
Fiji	1.16	134
Samoa	1.12	135
Guatemala	1.08	136
Honduras	1.07	137
Eswatini	1.05	138
Tajikistan	1.01	139
Tuvalu	1.00	140
Cape Verde	0.96	141
Mauritania	0.96	142
Pakistan	0.85	143
Nicaragua	0.80	144
Sri Lanka	0.79	145
Papua New Guinea	0.77	146
Senegal	0.67	147
Myanmar	0.65	148
Vanuatu	0.64	149
Benin	0.63	150
Ghana	0.62	151
Bangladesh	0.60	152
Nigeria	0.59	153
Sao Tome and Principe	0.58	154
Zimbabwe	0.54	155
Kiribati	0.52	156
Nepal	0.51	157
East Timor	0.50	158
Comoros	0.49	159
Sudan	0.47	160
Kenya	0.46	161
Angola	0.45	162
Zambia	0.45	163
Cote d'Ivoire	0.42	164
Solomon Islands	0.41	165
Djibouti	0.40	166
Guinea	0.36	167
Cameroon	0.34	168

Country	CO_2 Per Capita Emissions (tonnes per person)	Rank
Yemen	0.34	169
Mali	0.31	170
Afghanistan	0.30	171
Togo	0.29	172
Gambia	0.29	173
Burkina Faso	0.26	174
Mozambique	0.24	175
Tanzania	0.24	176
Haiti	0.21	177
Eritrea	0.19	178
South Sudan	0.17	179
Liberia	0.17	180
Ethiopia	0.16	181
Guinea-Bissau	0.16	182
Madagascar	0.15	183
Chad	0.13	184
Sierra Leone	0.13	185
Uganda	0.13	186
Niger	0.12	187
Rwanda	0.11	188
Malawi	0.10	189
Burundi	0.06	190
Central African Republic	0.04	191
Somalia	0.04	192
Democratic Republic of Congo	0.04	193

Source: Based on Global Carbon Budget (2023) and Our World in Data (2024)

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Emissions and Consumption: An Approach to Climate Justice

Abstract

The paper explores the relationship between CO_2 emissions and consumption and argues that high and unsustainable level of per capita consumption is the primary driver of climate change. High level of consumption in developed countries affects the right of every individual across the globe to have equal access to atmospheric resources and results in climate injustice. In the interest of early stabilization of climate change, effective international climate actions must aim at reducing unsustainable levels of consumption of energy and emissions in developed countries and providing equitable access to energy and resources in developing countries. Sustainable consumption and equitable energy access are keys to ensuring climate justice and early climate stabilization.

Keywords

Climate justice, consumption, energy access, equity, climate stabilization