Working paper

Improving living standards within stringent carbon budgets

The critical importance of climate equity

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Key messages

In the past 30 years, inequality within countries has become an increasingly important driver of emission inequality, with carbon footprints closely linked to income and consumption.

The bottom three-quarters of the global consumption distribution based in low- and middle-income countries outside Europe have considerably lower per capita expenditures, on average, than their counterparts in European upper-middle-income countries and high-income countries. This difference would be even starker if considering other Western nations (e.g. United States, Canada or Australia) or other high-income countries (e.g. those in the Persian Gulf).

National averages conceal stark differences within countries. The wealthiest Indians or Nigerians, for instance, may emit as much as Australians. However, our findings underscore that most Indians or Nigerians have very small carbon footprints, unlike the average or even poorer Australian.

Even if we raise the living standards of billions of people who now consume too little for their own well-being, their per capita emissions would still be very low and even their aggregate emissions quite modest. The continued deprivation of people in poverty won't save the planet from climate change.

There are low-carbon options for reliable power, access to goods and services, and nutrition. The relative affordability and viability of these options are shaped partially by exogenous factors such as technological costs, established infrastructure stock and availability of land, but also endogenous factors such as regulatory environments, planning decisions, acquired capabilities and cultural norms.

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Acronyms/Glossary

CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
GHG	greenhouse gas
GT	gigatonnes
HIC	high-income country
LIC	low-income country
LMIC	lower-middle-income country
MIC	middle-income country
NDC	Nationally Determined Contribution
tCO_2e	tonnes of carbon dioxide equivalent

1 Introduction

The impacts of climate change are increasingly visible around the world: from hotter summers across northern latitudes, to thinning ice cover at the poles, to alternating periods of drought and destructive rains in the tropics, to more frequent and severe storms (IPCC, 2022a). In response, many governments and private actors have pledged to reach net-zero emissions by mid-century, but in practice few are decarbonising at sufficient pace to meet the temperature targets of the Paris Agreement (UNCC, 2022). Global greenhouse gas (GHG) emissions – and the resulting atmospheric concentrations – continue to rise (WMO, 2022; IEA, 2022b). The world is already about 1.2°C warmer, on average, than in pre-industrial times, and with current policies, warming is projected to reach 2.7°C by 2100.[1] Within the next few decades, without substantial adaptation efforts we can expect worsening disasters, growing water insecurity, reduced crop yields and increased crop losses, disruptions to economic activities, and widespread human suffering and displacement (IPCC, 2022a).

Urgent action is needed to avert that outcome. Yet political leaders also disagree on how much of the burden of climate action should fall on their respective countries (Maizland, 2023), and none are attempting to roll back their emissions quickly enough to allow poor countries a fair share of emissions. Even in those countries with more ambitious climate goals, political leaders tend to prioritise the development needs of their own citizens in the event of shocks and stresses, sometimes directly in conflict with climate action and the right of other countries' citizens to access their share of the carbon budget.

Climate justice demands that this sharing of the remaining budget should be equitable, and lots of options for deriving equitable emission reduction targets have been proposed (for example, see Peters et al., 2015; Tavoni et al., 2015; Pan et al., 2017; Holz et al., 2018). However, analysis of the first round of Nationally Determined Contributions (NDCs) suggests that countries largely conceive of equity in a self-interested way: that is, they choose definitions of equity that enable them to maximise their own emissions (du Pont and Meinshausen, 2018). The result of this self-interested approach is that collective pledges fall far short of the emission reductions required for 1.5°C or even 2°C.

This working paper examines the intersection of three global priorities: rapid reduction of poverty, inequality and emissions. Recognising that the climate, poverty and inequality crises are intertwined, the new findings in this paper support longstanding calls for a more equitable way forward. Drawing on new analysis, the paper shows how we can sharply reduce GHG emissions – without sacrificing prospects for development progress – if we prioritise sharp reductions in

1 See the Climate Action Tracker Thermometer: https://climateactiontracker.org/global/cat-thermometer. This is the median prediction; the projections range from 2.2°C to 3.4°C.

the emissions of the wealthiest people in the world, mainly in high- and upper-middle income countries, and use existing low-carbon measures to raise the living standards of the poorest people, mainly in low- and lower-middle income countries.

The paper begins with a discussion of the 'carbon budget' compatible with a 1.5°C climate target and different perspectives on equitable burden-sharing (Section 2). Then it presents new analysis of data on household consumption, energy use and GHG emissions across income quintiles, highlighting the outsize impact of the wealthiest people, globally and within countries (Section 3). Illustrative scenario modelling results are then presented to gauge the emission implications of ensuring that everyone has a basic, more equitably distributed bundle of goods and services, and of reducing the wealthiest people's consumption to create 'atmospheric space' to compensate (Section 4). Finally, it examines the feasibility of improving diets and meeting infrastructure needs while lowering emissions (Section 5). Based on this analysis, the paper ends with recommendations for improving the living standards of the poorest while avoiding runaway climate change.

2 Carbon budgets, equity, and the right to development

2.1 Where does the responsibility lie for climate change?

Looking forward, the climate crisis is a threat to development; looking back, it is the result of development choices made over several generations in richer countries. Contemporary debates around how to share the perceived burden of climate action need to be understood against this backdrop.

Historically, fossil fuel consumption has corresponded closely to economic development and poverty reduction. Coal fuelled industrialisation across the United States, Europe, Russia, Australia and China. Oil and gas underpin entire economies, and in many parts of the world remain essential for everything from transport, to heating and cooking, to plastics and chemicals. The construction of infrastructure and housing, which are essential for a decent quality of life, also produces substantial GHGs, even if they can thereafter be used and maintained with relatively low emissions.

In cumulative terms, the US is the largest emitter, responsible for an estimated 20% of global GHG emissions from 1851 to 2019; China is second, at 11%, followed by Russia (7%) and Brazil (5%) (Evans, 2021). However, given this paper's emphasis on human development, it is important to take population size into account as well. US cumulative per capita emissions far exceed those of China or India. The countries with the highest cumulative per capita emissions (as documented by Evans, 2021) are typically land-rich countries like Canada, the US and Australia; post-Soviet states like Russia, Kazakhstan and Estonia; and early industrialisers like Germany, the UK and Belgium.[2] All of these countries have high annual per capita incomes by global standards (World Bank, 2023a).

The United Nations (UN) climate accords of 1992 and 1997 originally placed the burden of climate change mitigation upon industrialised countries, including members of the Organisation for Economic Co-operation and Development (OECD) economies in transition (former Soviet states). The climate accords were designed in this way because these countries had made an outsized contribution to the increased concentration of GHGs in the atmosphere. This remains true: 58% of cumulative net CO_2 emissions from 1850 to 2019 occurred prior to 1990 (IPCC 2022b), and most of those early high-emitters have not significantly cut emissions.

However, in subsequent years, the annual emissions of some low- and middle-income countries began to rise substantially as their economies and energy use grew. Most notable among these was China's rise as an industrial powerhouse, although a number of other countries also achieved

2 The analysis by Evans (2021) includes LULUCF which materially changes the 'top 10'.

high-income status through structural economic transformation (for example, Chile, Singapore and South Korea) or the export of oil and gas (for example, Qatar, Saudi Arabia and the United Arab Emirates). In both cases, improvements in income correlated with increases in per capita emissions.

Today, China is the world's largest annual emitter in aggregate terms, emitting an estimated 12.06 billion tonnes of carbon dioxide equivalent ($GtCO_2e$) in 2019, or 28% of the global total (Climate Watch, 2022). The US is second, at 5.77 Gt (12%), and India is third, at 3.36 Gt (7%). However, looking at emissions relative to population size is again illuminating. If everyone in the world lived like the average American, the carbon budget would long have been spent. Per capita annual emissions in the US were 17.58 tCO_2e in 2019, compared to a global average of 6.48 (Climate Watch, 2022). Eleven countries averaged more than 20 tonnes per capita in 2019, including Canada (20.59) and Australia (23.99). Moreover, the world's 12 largest per capita emitters are major fossil fuel producers, mostly in the Persian Gulf, plus Canada, Australia, the United States and – rather unexpectedly – Luxembourg (World Bank, 2023b). The last is a quirk of carbon accounting: Luxembourg has very high fuel sales as people from neighbouring countries visit to purchase cheaper petrol and diesel.

However, some European countries have significantly lower per capita annual and cumulative emissions, including major economies such as France (5.24 tCO_2e in 2019) and Italy (6.30 tCO_2e in 2019). These outliers suggest that it is possible to achieve high incomes and living standards without pursuing such carbon-intensive development paths. At the same time, these are still high emissions, albeit lower when assessed relative to other high emitters. Later sections of this paper will further unpack the extent to which fossil fuel consumption, economic development and poverty reduction are necessarily interlinked.

Nevertheless, in the last 30 years, inequality within countries has become an increasingly important driver of emission inequality, as carbon footprints are closely linked to income and consumption. A sectoral example with food is presented in Box 1. In 1990, 62% of carbon inequality was due to inequalities in the average carbon footprints between countries. By 2019, 64% of carbon inequality was due to inequality of emissions between income groups *within* countries (Chancel et al., 2023). The global top 10% of emitters are responsible for almost half of all emissions, while the bottom 50% of the world's population are responsible for less emissions than the top 1% (ibid).

Box 1 Inequalities in the food sector

The ongoing inequalities of both living standards and GHG emissions can perhaps best be illustrated with a sectoral example: food. A nutritious and varied diet is crucial to human well-being. Yet food insecurity, malnutrition and outright hunger remain common in many parts of the world, exacerbated by the Covid-19 pandemic and, most recently, by the food shortages and price spikes caused by the war in Ukraine (Georgieva et al., 2022).[3] In 2021, an estimated 2.3 billion people – around 29% of the world's population – are moderately or severely food insecure, while 9.8% are undernourished. But food insecurity is not distributed equitably across regions and income levels: while 57.9% of Africans faced moderate or severe food insecurity, only 8% in North America and Europe did. Yet at the same time, the overconsumption of certain foods, such as red and processed meats, can cause cardiovascular disease, diabetes and other serious illnesses (Godfray et al., 2018). Meanwhile, food systems are also one of the biggest contributors to climate change, responsible for a third of global anthropogenic GHG emissions, much of it through land use (Crippa et al., 2021). Changing levels and types of food consumption – primarily in upper-middle and high-income countries as well as among the rich in poor countries – are therefore fuelling global warming without necessarily delivering better living standards, even while billions remain food insecure, hungry, or malnourished.

2.2 Who decides how to use the remaining carbon budget?

If global warming is to be kept below 1.5°C, scientists have estimated, total cumulative emissions from 2020 onward must be limited to 500 $GtCO_2$ (IPCC, 2022b).[4] For comparison, cumulative net CO_2 emissions between 2010 and 2019 were about 400 $GtCO_2$. By the end of this decade, the remaining carbon budget is likely to be exhausted based on current policies and actions. Many mitigation scenarios rely on 'negative emissions' from large-scale reforestation, carbon capture, utilisation and storage (CCUS) technologies and other measures to allow for some 'overshoot' of 1.5°C, but significant questions have been raised about their ethics and viability (see, e.g., Carton et al., 2020).

3 See also the World Food Programme's 'A Global Food Crisis' website: www.wfp.org/global-hunger-crisis.
4 This is the current central estimate for a 50% probability of limiting warming to 1.5°C (IPCC 2022b). Note that this only applies to CO_2; depending on assumptions about non-CO_2 mitigation, budget estimates vary by ±220 Gt CO_2; there are also uncertainties about geophysical processes.

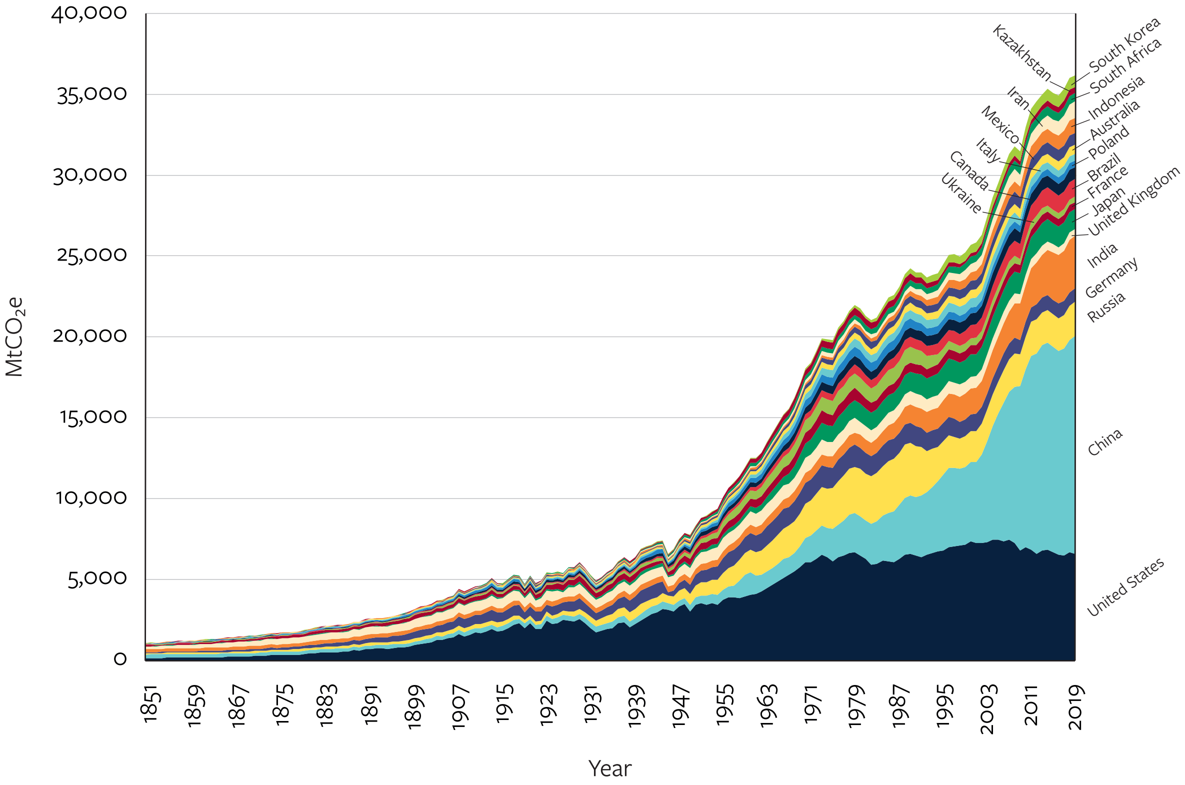
Most high-income countries named above have pledged to reduce emissions for over two decades.[5] Yet, by building economies that rely heavily on fossil fuels, and then making only modest efforts to reduce their emissions, these countries used up almost all the carbon budget available for 1.5°C, leaving very little for the rest of the world. Much of the remaining atmospheric space has been used by China (12.7% of cumulative emissions as of 2017), India (3%), South Africa (1.3%) and Mexico (1.2%) (Ritchie, 2019), which have either industrialised relatively recently or seen the benefits of industrialisation distributed unequally. Clearly not enough attention is being paid to the implications of these choices not only for the climate, but for poorer countries' development prospects.

The failure of most high-income countries to decarbonise coupled with rising emissions from some low- and middle-income countries has demanded a different approach to burden sharing within the UN climate accords. The Paris Agreement offered a partial solution with its bottom-up architecture. Rather than imposing top-down emission reduction targets like the earlier Kyoto Protocol, the Paris Agreement invites countries to submit NDCs that reflect their 'common but differentiated responsibilities and respective capabilities'. This bottom-up approach sidesteps the contentious issue of assigning responsibility for climate mitigation (Falkner, 2016; Pauw et al., 2019). However, as outlined above, this has also allowed countries to define what an equitable pathway to net-zero looks like in ways that best suit them, such that pledges collectively fall far short of the temperature targets in the Paris Agreement. Importantly, the first NDCs submitted by the G8 countries (including European Union member states) and China all fell short of even the most favourable interpretations of their fair share (du Pont and Meinshausen, 2018). Thus, many of the world's largest emitters – whether defined in historical or annual terms – are also planning to consume an outsized proportion of the remaining carbon budget.

Given the limited atmospheric space left, much of the policy debate has suggested that lower-income countries face two options: they must either find zero-carbon ways to lift their people out of poverty, build out their infrastructure and provide basic services and raise living standards, or knowingly pursue development paths that make catastrophic climate change likelier. This is deeply unjust, as Southern political leaders, scholars and advocates have been noting for decades. These are also not the only options, if the highest emitters curb their emissions, as we discuss in-depth below.

5 Countries that were industrialised as of 1990 (37 overall, plus the European Union, with special provisions for 'economies in transition' in Central and Eastern Europe) had obligations under the Kyoto Protocol, which was ratified in 1997, but only entered into force in 2005. See https://unfccc.int/kyoto_protocol.

Figure 1 GHG emissions of the top 20 highest-emitting countries over the period 1851–2019



Data source: Climate Watch (2022), using estimates from PIK (gases covered by the Kyoto Protocol).

2.3 What would be a more equitable way to divide up the carbon budget?

There is a robust body of literature on climate justice, equity and the right to development, beginning with Agarwal and Narain's seminal critique of 'environmental colonialism' in climate debates, demonstrating how Western institutions minimise their countries' historic and ongoing contributions to climate change (Agarwal and Narain, 1991). The Greenhouse Development Rights framework sought to ensure that wealth disparities are not baked in by a climate mitigation system with a focus on slashing emissions from the wealthy while preventing drastic increases among people in poverty (Baer et al., 2009). More recently, Kartha et al. (2018) challenge the dominance of grandfathering and cost minimisation approaches in mapping mitigation pathways, given that both implicitly privilege countries that have produced substantial emissions or have higher incomes (with these two characteristics being interlinked).

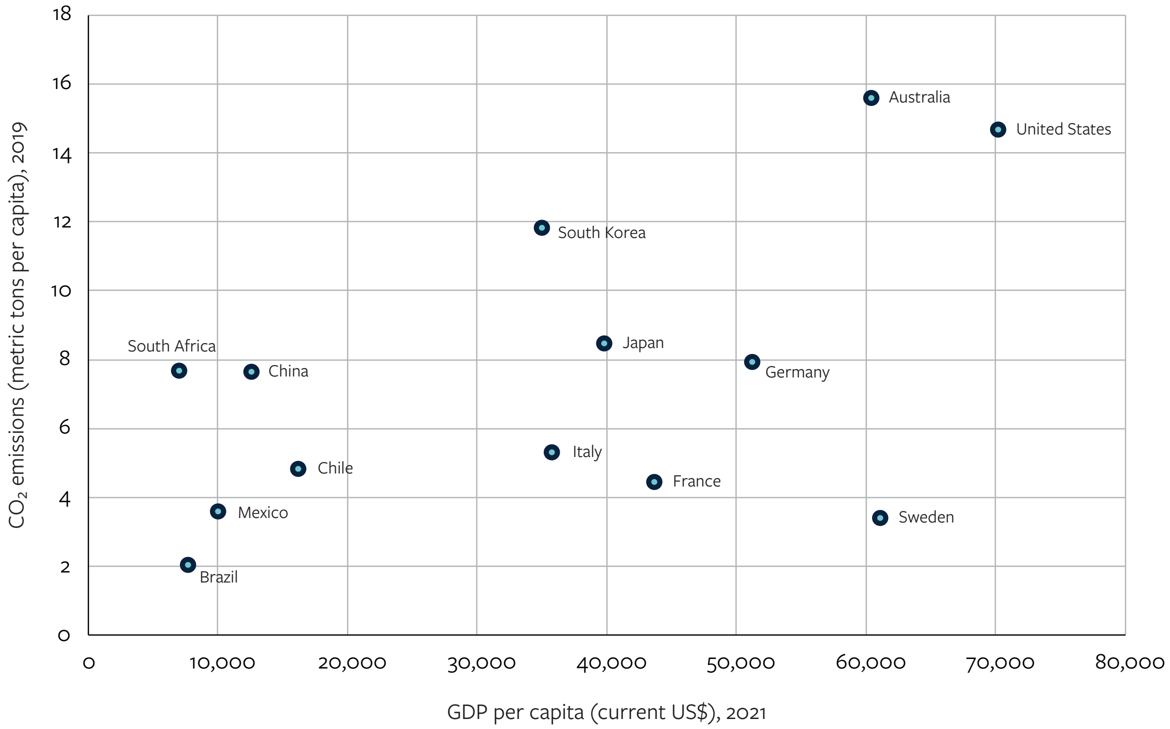
At the core of all this work is the idea that the poorest people in the world should not be deprived of development in the name of decarbonisation, nor should they bear the cost of climate change mitigation. The Greenhouse Development Rights framework, for instance, sets a welfare threshold below which people should not be expected to share the costs of the low-carbon transition (Baer et al., 2009). The line is deliberately set well above the extreme poverty threshold, but below 'affluent' consumption levels. Everyone else's 'fair share' of the remaining carbon budget is then calculated as a function of their historical responsibility and capabilities, in line with the core principles of the global climate regime. The Greenhouse Development Rights framework has now evolved into the Climate Equity Reference Project, using indicators of responsibility, capacities and development needs to assign the remaining atmospheric space among nations. A clear oversight is that it is only between and not within nations.

The good news for countries at all levels of economic development is that there is not necessarily a stark choice between improving living standards and avoiding GHG emissions. The very large differences in the per capita emissions of high- and upper-middle income countries demonstrates how societal and historical choices about infrastructure, urban form and individual behaviour can lead to dramatically different levels of per capita emissions. It is therefore very much possible to achieve high living standards without high emissions, as evident in Figure 2. Countries like Brazil, Chile and Mexico have comparable average incomes to China and South Africa with less than half the per capita emissions. We see a similar gap between France and Italy on the one hand, and Japan and South Korea on the other. Sweden offers an especially stark counterpart to Australia and the United States, with similar incomes of over $70,000 per person but with just a quarter of the per capita emissions. However, this does not suggest that one country can or should become another: emissions are one of the results of countries' development histories and path dependence is not easy to escape.

The difference in per capita emissions between countries are often determined by the historical choices societies make, rather than individual contemporary behaviour. Economic structures determine carbon footprints and create path dependencies that make the individual and social behaviours required for net zero considerably more expensive. Road traffic infrastructure decisions, for example, can tie societies into carbon-intensive local transport or provide carbon-extensive alternatives, such as active or public transport. This also relates to a 'systems of provision' approach, where elements underpinning the political economy of resource use and consumption are interlinked (e.g. see Mattioli et al., 2020, for an application to car dependence). For poor countries, therefore, it is essential that they embark upon carbon extensive forms of development. For rich countries, the challenge is to invest sufficient funds and incentivise the necessary degree of behaviour change to escape the path dependencies that would otherwise result in catastrophic climate change.

The sharp decline in the cost of renewable energy in the past decade, particularly solar, but also wind as a cheap and widely available energy source, has further improved the economics of low-carbon development (IEA, 2022a) relative to a traditional, fossil fuel-powered path. Moreover, there is an extensive body of literature documenting potential synergies between development and climate mitigation, particularly in public health but also with respect to such diverse areas as energy and food security, labour productivity and ecosystem function (for example, see McCollum et al., 2013; Valin et al., 2013; Ürge-Vorsatz et al., 2014; Haines, 2017; Deng et al., 2018).

Figure 2 Per capita incomes and emissions of selected high- and upper-middle income countries



Source: World Bank (2023a; 2023b)

However, the strong evidence of co-benefits relating to climate action has not sufficiently answered countries' legitimate concerns about trade-offs between poverty eradication and climate action. Some modelling validates these concerns, suggesting that stringent climate mitigation policies could potentially slow the rate of poverty reduction over the next decade in the absence of sufficient international support and action (Hasegawa et al., 2018; Campagnolo and Davide, 2019; Nerini et al., 2019). Note that these studies do not take into account greater climate change impacts with lower rates of emission reduction: the overwhelming scientific consensus is that, over the longer-term, higher levels of warming will reduce economic growth and increase inequality and poverty levels, especially across the global South (Pörtner et al., 2022). Nonetheless, a key challenge in promoting a more equitable allocation of the remaining carbon budget is to recognise and address the implications for human well-being. Exploring those implications in depth is beyond the scope of this paper. However, by analysing some basic data on household spending across countries and income groups, as well as associated energy use, it is possible to identify broad patterns to guide further discussion.

3 Mapping consumption and emission levels across income groups

Decent living standards entail some degree of material consumption (e.g. food, energy, transport) – which itself is only part of the context of wider emissions globally. At the same time, it is widely recognised that current aggregate consumption levels are unsustainable, primarily due to the outsized footprint of the wealthiest countries and people in the world. Significant research and analysis has been done to try to find the right balance, including the highly influential "doughnut economics" concept (Raworth, 2012). The core idea is to identify a 'safe and just space' bounded by the planet's biophysical limits (grounded in the considerable scientific literature on planetary boundaries (Rockström et al., 2009; Steffen et al., 2015) and core human needs (which can also be extended to and through the political process of negotiating the Sustainable Development Goals). Greater equity within and between countries in the use of natural resources is fundamental to achieving that objective, along with far more efficient use of resources – from energy to food crops.

Scientists have developed numerous scenarios for reducing GHG emissions globally to net zero by mid-century (see, e.g., IEA, 2021b; IPCC, 2022b), and scenarios have also been developed for achieving net zero emissions within specific countries. However, even those scenarios assume that meeting human needs will produce some emissions, which are offset by different means, and the transitions they envision are expected to take decades. Until then, and knowing that even poverty-level consumption has a (small) carbon footprint, we need to assume that ensuring that even the poorest people have decent living standards will increase GHG emissions to some extent (Grubler et al., 2018; Millward-Hopkins et al., 2020). In this section, we consider the carbon footprint of current consumption patterns by different income groups within and among countries, and the increased emissions illustratively associated with increasing the consumption of the poorest. The findings build on the literature to consider how much of the remaining carbon budget might be required for poverty reduction, and thus whether the proposed net-zero targets and pathways of higher-income countries are leaving sufficient atmospheric space for lower-income countries to achieve basic levels of human and economic development.

3.1 Data and methods

There are two parts to our analysis: the first is to estimate the energy footprints corresponding to different income groups, overall and by consumption sectors (food, electricity and heating, household appliances and services, health and transport including vehicle purchase alongside fuel and maintenance), with the aim of drawing attention to disparities in carbon footprints. The second is to model the carbon implications of adjusting consumption levels for greater equity in living standards between and within countries. We don't aim to replicate estimations of energy requirements of decent living standards (however defined), but rather seek to understand what existing estimates of those requirements suggest for different countries and for population consumption segments within those countries. To do so, we analyse between- and within-country variations in GHGs emissions across a number of sectors. In this process, we draw attention to carbon footprints corresponding to different country income groups, overall and by the sectors identified above. This is a descriptive analysis of the merged expenditure–energy dataset.

For this analysis, we used household survey data from 86 countries for the year 2010 as well as energy extended multi-regional input-output (MRIO) modelling results. The survey data were assembled and classified by Oswald et al. (2020), who also produced the models.

- The **household budget surveys** (see Annex for a list of the 86 countries) capture 85.8% of people living below the global extreme poverty threshold (US$2.15 per day in 2017 Purchasing Power Parity terms). The data come from two repositories. The first is the World Bank's Global Consumption Database, which includes low- and middle-income countries (LICs and MICs) and disaggregates within-country data from 2010 into four income thresholds ($0–2.97 per capita per day, $2.97–8.44, $8.44–23.03, and over $23.03). Those categories correspond to the bottom half of the global consumption distribution, the 51st to 75th percentiles, the 76th to 90th percentiles, and the top decile. The second source is a database of Eurostat household budget surveys, which includes the 28 Member States as of 2010, as well as Norway and Türkiye. These are mainly high-income countries (HICs), along with three upper-middle-income countries (UMICs): Türkiye, Romania and Bulgaria.
- The **energy modelling results** are based on data from the Global Trade Analysis Project (GTAP 9)[6] for 2011 and International Energy Agency energy balances for the same year. The constructed dataset provided in Oswald et al. (2020) combines the energy balances with household budget surveys data for 2010 (see above) and makes projections to 2030, extrapolating expenditure and energy patterns based on projected economic and population growth.

There are important limitations to these datasets. They are from 2010, and thus may not accurately reflect current conditions. The projections to 2030 may also no longer be realistic, and they are also simplified, assuming economic growth is uniformly distributed between consumption segments within countries. Country coverage is also limited, comprising just 12 out of 28 LICs (and just six when converting energy data to GHG emissions), 24 of 54 lower-middle-income countries (LMICs), 23 of 54 UMICs, and 27 of 81 HICs. Given the small number of LICs in the GHG sectoral data, we present some carbon energy analysis that captures a wider number of countries alongside our more focused sectoral analysis relying on the GHG emissions data. Finally, in all of this, our focus is mainly on monetary dimensions of welfare through expenditure metrics, which is a limited view of improving living standards. At the same time, boosting incomes of people in poverty remains extremely important in LICs and many LMICs, and so is a key component in discussions of improved living standards as presented in this analysis.

6 See www.gtap.agecon.purdue.edu/databases/v9.

For the first part of our analysis – to assess the carbon footprint of different patterns of consumption, we translate the energy data into GHG emissions estimates.[7] Importantly, we were only able to examine sectors covered in both the household budget survey and energy models, which means that our analysis is limited to five sectors more relevant for living standards: food, electricity and heating, household appliances and services, transport and health. However, these sectors tend to account for a large share of GHG emissions associated with quality of life for low-income groups.

To translate energy data into GHG emissions estimates of these five sectors, we multiply the energy data by standard GHG footprints per energy use that are available for a range of sectors in each country. For example, the heating and electricity and household appliances and services energy data is converted to GHG values using the GHG footprints of the residential intensity sector; the health sector relies on the 'commercial and public services' intensity sector for GHG conversions; and the transport energy data relies on the GHG footprints for the transport intensity sector.[8]

To assess living standards, we use the data on household budgets to form a monetary measure of total consumption per capita, disaggregated by consumption segment. We also try to assess multiple dimensions of wellbeing through per capita spending on the five sectors identified above. We focus on food and health spending as key indicators of minimum living standards and wellbeing, as evidenced by their inclusion in various multidimensional poverty indices. Electricity and transport are often key enabling infrastructure in pathways out of poverty and towards structural economic change, especially in urban areas (Collier and Venables, 2016; Duranton and Venables, 2018), while spending on household appliances and services can serve as proxies for living standards (Diwakar and Shepherd, 2022). Together, these sectors provide key indicators of human well-being.

We recognise that spending on goods and services is in some ways a poor measure of living standards, given how the costs of provision and access are shaped by policies, infrastructure stock, geography and other factors. Thus, the cost of essentials such as a nutritious diet may vary among countries. And within countries or even within cities, the costs of essentials such as clean

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7 In this process, six countries (Burkina Faso, Guinea, Madagascar, Malawi, Rwanda and Uganda) were removed from the dataset due to limited data on GHG intensities.

8 The energy data for the food sector is converted using the GHG footprints per energy use that is an average across the agricultural, industry and residential intensity sectors. This would vary depending on whether a country is a large food importer (in which case the domestic agricultural multiplier is unlikely to be representative) as well as the type of foods in diets (e.g. where there is a lot of processed food reliant on industry, this might correspond more closely with the residential sector intensity). In addition, we also create bounds per country, using the highest and lowest GHG intensity sector amongst these three sectors to represent upper and lower bounds respectively, as highlighted in Figures 4 and 5.

drinking water may vary depending on the extent and quality of piped water infrastructure (Beard and Mitlin, 2021). Nevertheless, assessing expenditures provides arguably the best available proxy for living standards.

For our thought experiment, we then undertake a simplistic modelling exercise to understand the carbon implications of adjusting consumption levels to achieve more equitable outcomes between and within countries. To do so, we crudely estimate what might be the GHG emissions per capita linked to households moving between consumption segments, overall and again by sector, for 2010 and 2030 projections, and differentiated once more by country income group. In particular, we first examine the emissions implications of all households in the poorest consumption segment moving up to the next lowest segment, followed by progressively moving consumption segments to higher groups within their countries. Finally, we consider the carbon implications of cutting emissions for the rich as a way to offset boosting emissions for people in and near poverty. These illustrative modelling exercises recognise that options are often 'baked in' by infrastructure and other systems.

For the sake of simplicity, we assume that as people move across consumption segments, all else remains equal, which may not be the case in practice. Indeed, the lifestyles of the richest people, at least in some countries, may rely on a large base of low-paid workers living in or near poverty. We also assume that LICs and LMICs can build the productive capacities necessary for a competitive industrial sector, which many have sought unsuccessfully to do for decades. Again, these choices reflect our intention not to build a new general equilibrium model, but rather to sketch out, in broad strokes, the atmospheric space needed and available to enable a shifts to more equitable living standards. This exercise is thus meant as an illustrative conversation starter that could lead to deeper analysis.

3.2 Carbon and consumption inequalities within countries

Table 1 provides a breakdown of the global population by income group and country income classification. For context, along with smaller countries, the LMIC group includes India, Indonesia, Pakistan, Nigeria and Viet Nam; China, Brazil, Mexico, Russia and Türkiye are among the UMICs. Notably, although there are richer and poorer people in every country, the vast majority of people in low- and lower-middle-income countries are in the bottom half of the global income distribution, while very small numbers belong to the top decile. For example, from Table 1, it is primarily the top decile and middle segment in UMICs which might feature strongly in absolute terms as polluters. The top decile and middle segment in LMICs also are part of this group of strong polluters, but comprise just 73 million people.

The European countries in the Eurostat database are predominantly HICs, except for three UMICs (Türkiye, Romania, and Bulgaria). It is especially important to note that European countries on average have much lower per capita emissions than other major Western economies (i.e. United

States, Canada and Australia) thanks in part to Europe's more dense and well-connected urban areas and – frequently if not universally – greener electricity systems, and so our analysis based on this sample is likely to underestimate GHG emissions in HICs as a whole.

Table 1 Population of 86 studies analysed, by consumption segment and country income classification (2010)

Consumption segment	Country income classification	Population (million)
Lowest half (up to 50th percentile)*	LIC	252.8
	LMIC	1,918.0
	UMIC	673.0
Low (51st–75th percentile)	LIC	46.64
	LMIC	480.9
	UMIC	857.4
Middle (76th–90th percentile)	LIC	2.49
	LMIC	70.42
	UMIC	464.5
High (top decile)	LIC	0.15
	LMIC	2.64
	UMIC	82.69
Europe Q1*	HICs /UMICs	116.5
Europe Q2	HICs/UMICs	116.5
Europe Q3	HICs/UMICs	116.5
Europe Q4	HICs/UMICs	116.5
Europe Q5	HICs/UMICs	116.5

* As noted at the start of this section, the upper four categories are the ones used in the World Bank's Global Consumption Database and reflect the global income distribution as of 2010; they are applied to the 56 countries for which consumption data were taken from that database. Q1, Q2, etc. refers to income quintiles (lowest 20%, second-lowest, and so on) for the 30 countries for which data were obtained from the Eurostat database – all high-income countries, except for Türkiye, Romania and Bulgaria, which are upper-middle-income (see Annex). Note that the population numbers and income classifications are as of 2010; the World Bank updates income classifications annually (see Hamadeh et al., 2022).

Source: Authors' analysis based on Oswald et al.'s (2020) collated dataset

Figure 3 shows average per capita expenditure by consumption segment across country income groups. Given that segments are constructed based on global income distribution data, there are not large disparities in expenditure within income categories across country income groups; in other words, the wealthiest 10% residing in LICs globally have comparable levels of spending to those residing in LMICs and UMICs. The largest difference is among the poorest 50% in LICs and

MICs globally, when compared to the poorest quintile in Europe. For example, the poorest 50% have average annual per capita expenditures between US$502 and US$844 in LICs and MICs. Instead, the poorest 20% have average annual per capita expenditures of US$1,973 in Europe. Moreover, there are large disparities in expenditure among income categories within countries at all income levels. On average, for every US$1 spent by the poorest 50% of the global population residing in LICs, the top 10% spends US$29.

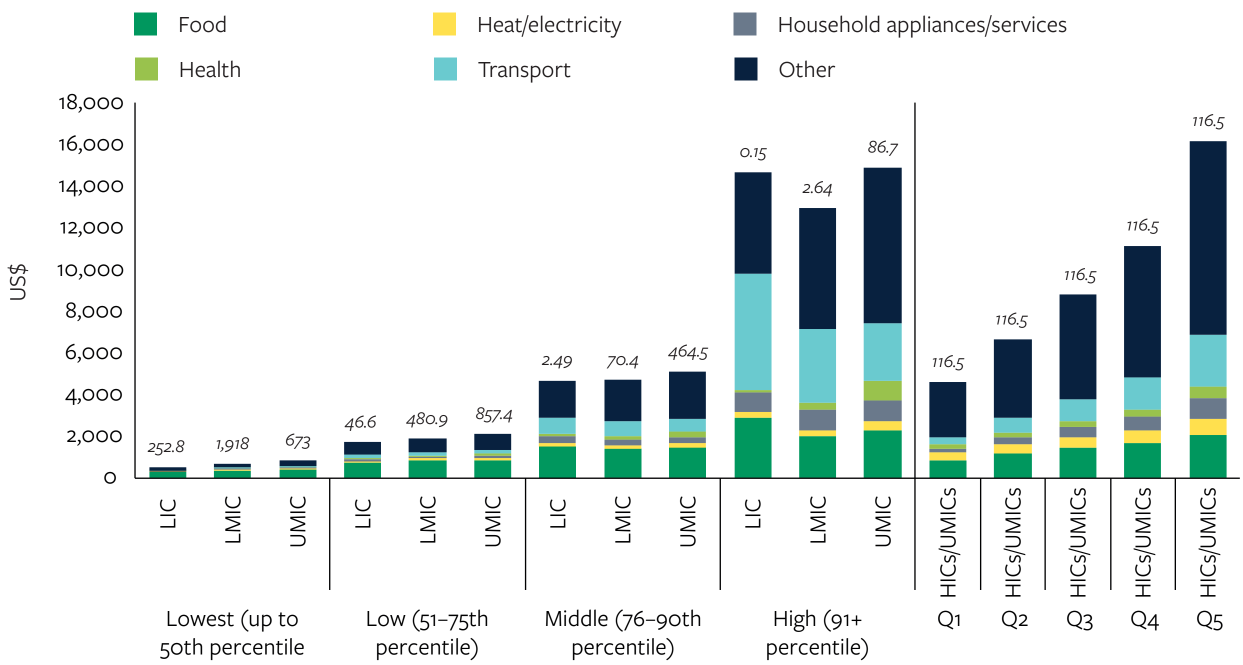
The share of total expenditures in sectors relating to living standards[9] (as a share of total household expenditures) also varies significantly, ranging from 50–67% of total consumption per capita on average in the richest 10% of the global population residing in LICs and MICs, to 69–74% of the bottom half of the global distribution in LICs and MICs. The sectoral breakdown of consumption among income groups within LICs and MICs varies as well, with much larger shares spent on transport in the richest decile while food accounts for the most substantial share of expenditure for the poorest five deciles.

It is striking to compare these figures to European UMICs and HICs. Notably, the bottom three-quarters of the global consumption distribution based in low- and middle-income countries outside Europe all have considerably lower per capita expenditures, on average, than their counterparts in European UMICs and HICs. It is only the top 25% of the global income distribution living in LICs and MICs who spend comparable amounts to even the poorest quintile in Europe. Yet the wealthiest 10% of the global population residing in LICs and UMICs of the Global South spend more per person than all but the richest 20% in European UMICs and HICs. Figure 3 therefore points to two conclusions: extreme inequality within LICs and UMICs of the Global South and a relatively high living standard for the poorest within European UMICs and HICS of the Global North.

At the same time, as high as per-capita household expenditures may be, the numbers of wealthy people are low: just 150,000 in the top global income decile in LICs collectively spending US$2.4 billion, and 2.64 million in LMICs collectively spending US$32.5 billion. Conversely, the households in the bottom half of the global income distribution, who spend up to US$2.97 per day, are so numerous – 2.8 billion just in the countries in the sample – that in the aggregate, their spending approaches US$2 trillion. These data underscore the extreme inequality within LICs and LMICs, but also demonstrate that the relatively small proportion of wealthy households mean that these countries collectively account for a relatively small fraction of total consumption expenditure.

9 Recall that we proxy these through the food, heat and electricity, household appliances and services, health and transport sectors to align with the constructed dataset.

Figure 3 Average annual per capita expenditure in 86 countries analysed, by global consumption segment and country income category



Note: Numbers in italics show the global population (in millions) for each subsegment

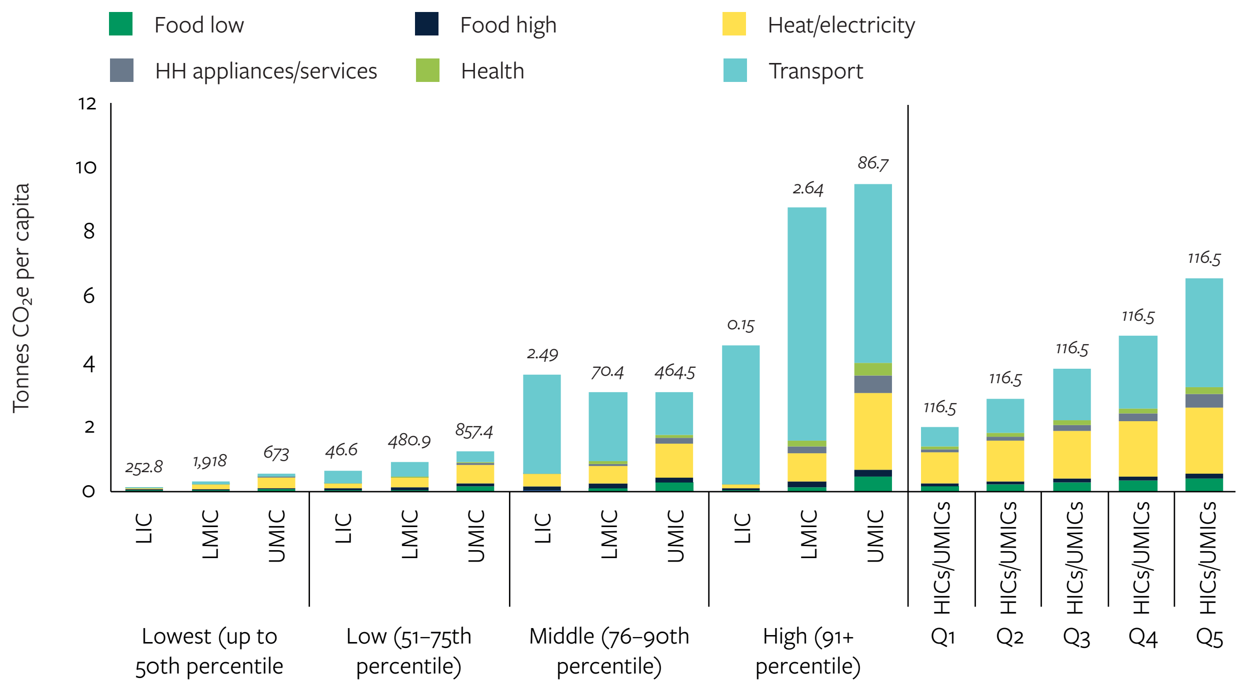
We see a different story emerging when we look at UMICs and HICs. People from UMICs from the Global South are much better represented in the global top 10% of income than those from LICs or LMICs, with 82.7 million people who collectively account for US$1.4 trillion of expenditure. The population of 2.1 billion people across the sample UMICs is notably smaller than that of LMICs (2.5 billion), yet their aggregate consumption expenditure is 2.5 times higher (although notably unequal, as shown in Figure 3). The contrast with European UMICs and HICs is even higher. The aggregate spending of just the lowest income quintile (Q1) in our European sample – population 116.5 million – far surpasses that of all people, across income categories, in LICs, which have a combined population of 302.1 million in our sample. To the extent that expenditure is a good proxy for consumption, Figure 3 demonstrates how the relatively high per capita consumption even of poorer groups in higher-income countries collectively outweighs that of lower-income countries.

Figure 4 shows rough estimates of how the household expenditure levels shown in Figure 3 translate into per capita GHG emissions. Here it is important to remember that, as discussed in Section 2, there are large differences in per capita GHG emissions across countries within income groups – even between neighbours in Europe. The carbon intensity of a country's power generation system, its dependence on private motorised transport and its economic composition (for example, the presence of hard-to-abate sectors like cement, chemicals, or iron and steel) will shape per capita emissions even more profoundly than per capita income in the years to come.

This explains the notable disparities among countries at comparable levels of income in Figure 3. With respect to Figure 4, it is especially important to note that European countries on average have much lower per capita emissions than other major Western economies (i.e. the United States, Canada and Australia) as noted above. If all high-income countries were included in the analysis, the bars on the right would look quite different.

This emphasises that the national averages conceal stark differences within countries. The wealthiest Indians or Nigerians, for instance, may emit as much as Australians. However, our findings underscore that most Indians or Nigerians have very small carbon footprints, unlike the average or even poorer Australian.

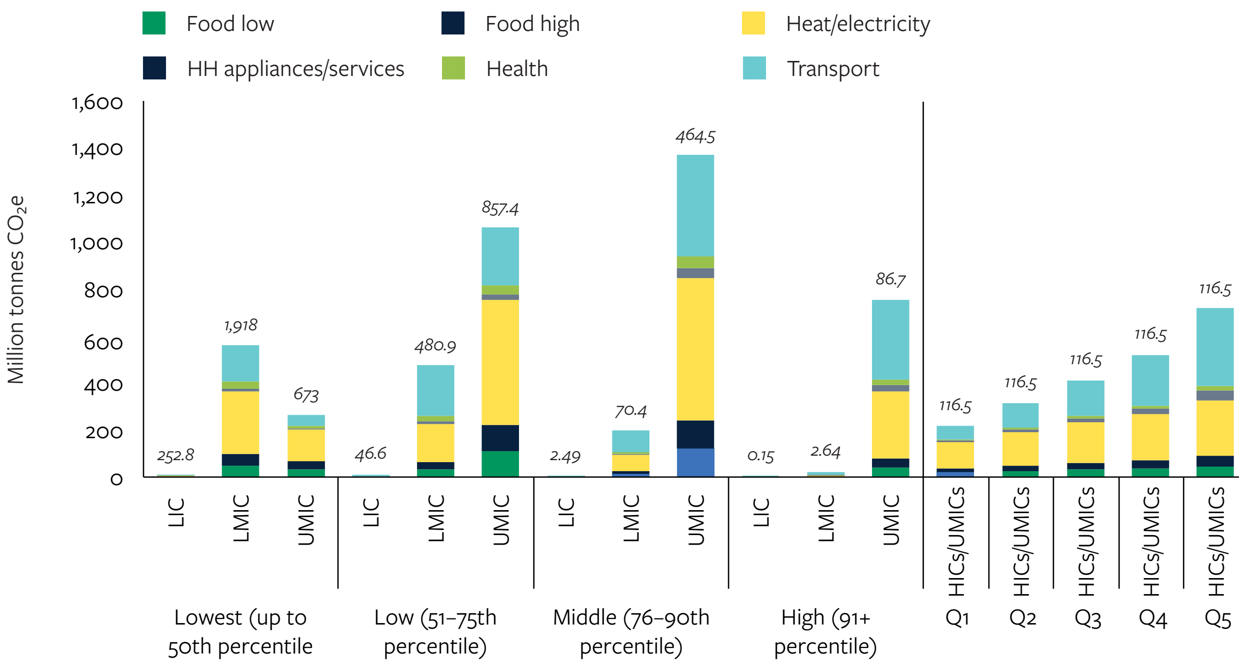
Figure 4 Estimated per capita GHG emissions associated with household consumption in 80 countries for which data were available, by global consumption segment, country income category and sector



Note: An average of GHG intensities of the agricultural, residential and industry sectors is used to convert the food energy to GHG footprint data (see Annex for more detail). Note also that due to data limitations, the LIC group here and comprises just six countries. Numbers in italics show the global population (in millions) for each subsegment

Again, at the aggregate level,[10] the collective carbon impact of people in UMICs, particularly wealthier households, is worth noting. While the emissions of the lowest nine deciles may remain relatively low in per capita terms, their aggregate impact is very substantial. Many of these countries have had energy-intensive economies with large industrial sectors for decades, including Kazakhstan, South Africa and Türkiye. However, given that China accounts for over half the population of UMIC countries, it is worth specifically noting how the recent growth and modernisation of its economy has changed global consumption, energy use and emission patterns such that countries in this income category must be recognised as a very substantial source of GHG emissions – in contrast to the early years of the UN climate accords. Across the board, it is worth noting that very high emissions among the wealthier households (including those in Europe) can be attributed to the heating/electricity and transport sectors, where choices around power generation, urban form and connective infrastructure shape the carbon intensity of living standards.

Figure 5 Aggregate GHG emissions associated with household consumption in the 80 countries for which data are available, by global consumption segment, country income category and sector

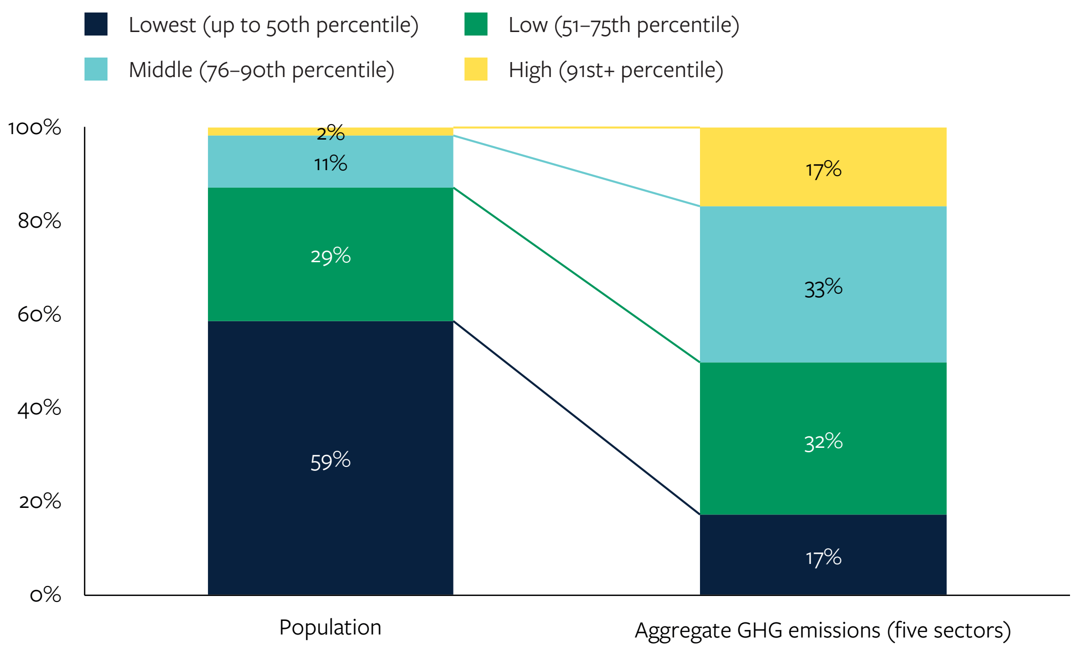


Note: Numbers in italics show the global population (in millions) for each subsegment

10 It is worth reiterating that our sample only includes six LICs, 24 LMICs and 20 UMICs in the Global South, plus 30 European countries. However, five of the top 10 cumulative GHG emitters in the world are included in the data: India and Indonesia among the LMICs, China and Brazil among the UMICs, and Germany among the European HICs.

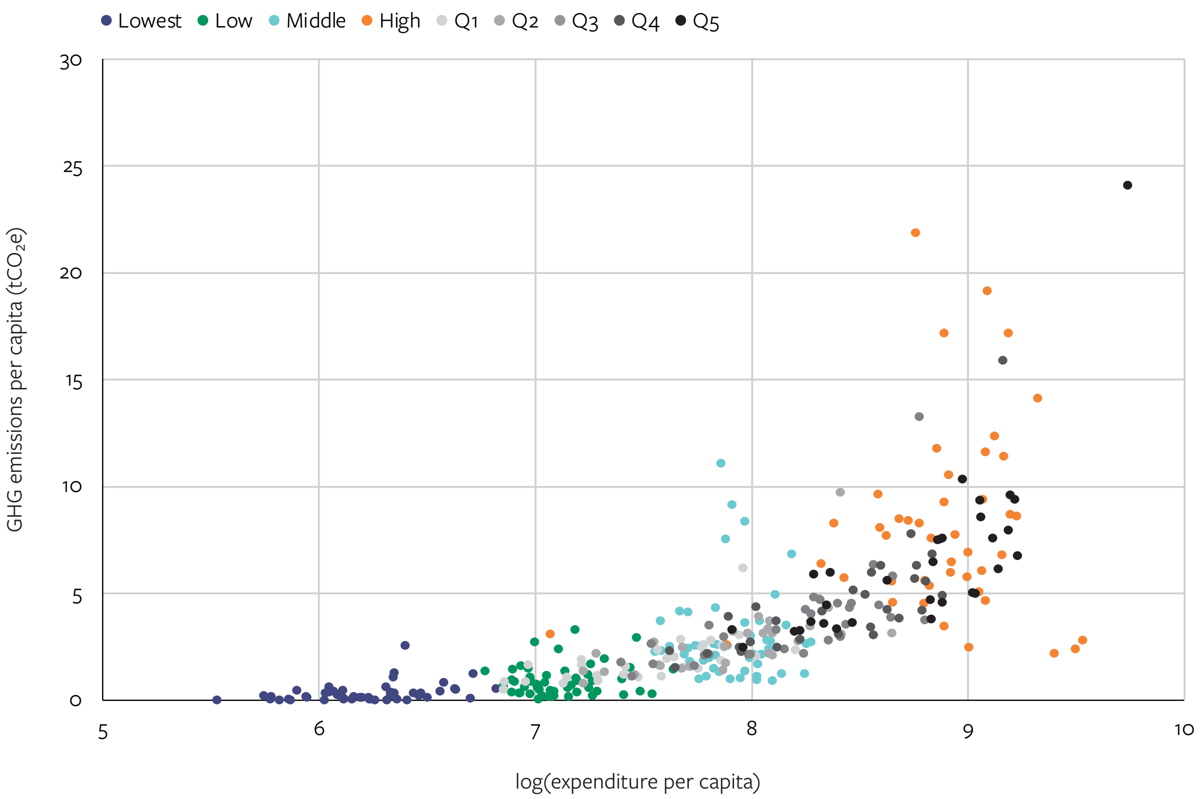
Looking within country income categories, we find that the wealthiest 2% of households living in the sample of LICs and MICs – the 85 million people who are in the top decile of the global consumption distribution – are responsible for the same aggregate GHG emissions (from food, electricity and heating, household appliances and service, transport and health) as the bottom 59% of households in those countries, the 2.8 billion people in the bottom half of the global consumption distribution. As shown in Figure 6, each group is responsible for 17% of GHG emissions across the five living standards sectors examined. This highlights the very small contribution of people in and near poverty to global GHG emissions. Our findings are consistent with recent analyses by – for example – Bruckner et al. (2022). However, our work shows that the inequities are just as stark when the analysis focuses more narrowly on emissions from sectors representative of living standards, and on a subset of LICs and MICs (i.e. rather than total carbon footprints at a global scale).

Figure 6 Population shares and corresponding shares of GHG emissions from sectors associated with living standards in the 50 LICs and MICs for which data were available



Digging deeper into differences within countries, Figure 7 shows average expenditure per capita, by consumption segment, and associated average per capita GHG emissions. It is clear that there is significant variation in levels of expenditure, and the emissions associated with that expenditure. While there is some relationship between low incomes and low emissions, it breaks down at higher levels of income. The findings demonstrate that it is possible to significantly improve incomes – and thus living standards – without a commensurate increase in GHG emissions. Indeed, we see from outliers in the bottom righthand corner that emissions might can remain very low at relatively high levels of income. The countries that stand out in this regard are Nepal, Ethiopia and Lao PDR. Conversely, the very high GHG emissions associated with the top consumption segments in some countries point to opportunities for reforms to reduce emissions without sacrificing good quality of life. The five countries that stand out in this regard are Mauritius, Luxemburg, Egypt, Nigeria, Kazakhstan and Kyrgyzstan. As discussed earlier, there is some path dependency in emissions footprints, and it may be much harder for some countries to reduce emissions than others. Nevertheless, these countries demonstrate that it is possible.

Figure 7 Distribution of annual per capita expenditure and GHG emissions by global consumption segment in 80 countries



4 Carving out atmospheric space: a thought experiment

Both the literature review and the empirical analysis above underscore that the wealthier people of the world take up an outsize share of the atmospheric space. However, their larger carbon footprints do not correspond perfectly with living standards: HICs and UMICs with comparable average incomes vary wildly in terms of their per capita emissions. This means that there are opportunities to achieve a high quality of life in a less carbon-intensive way, freeing up more of the carbon budget for poorer people to improve their living standards without exceeding global temperature targets.

The question then is, how should patterns of consumption change to mediate among these different objectives? Having discussed what the recent relationship between carbon footprints and different sectors for different consumption segments internationally looks like, we next conduct a thought experiment to try to quantify the climate implications of increasing the consumption of poorer populations – and the extent to which reducing consumption among wealthier people could offset those emissions. The analysis suggests that it is possible to significantly improve living standards in LICs/LMICs without significant emissions, and in turn that major emission reductions can be achieved by focusing on the choices and structures of the richest (mostly in HICs/UMICs, but also amongst the top consumption segments in LICs/LMICs). In HICs and among the wealthier populations within UMICs, there are even choices where improved health and well-being require the same changes as lowering carbon footprints. Perhaps the best example of this is the switch to diets richer in vegetables and plant proteins, as discussed above.

This is a thought experiment, not a detailed scientific analysis. As a reminder, the data used in our calculations are all from 2010, complete for only 80 countries, and our estimates of consumption, associated energy use and GHG emissions are rough averages. Moreover, the global economy has continued to evolve, advances have been made in energy efficiency, and the share of renewables and other zero-carbon energy sources in the global energy supply has grown. Still, the estimates we present here provide an indication of the scope of the challenge and the potential climate benefits of more equitable consumption.

4.1 Climate implications of raising the consumption floor

The first step in our analysis is to calculate how much per capita GHG emissions would increase if people in the lowest consumption segments moved up to a higher segment. As a reminder, for the 50 low- and middle-income countries in the World Bank's Global Consumption Database, the segments are US$0–2.97 per capita per day (bottom half of the global consumption distribution); $2.97–8.44 (51st to 75th percentile), $8.44–23.03 (76th to 90th percentile) and over $23.03 (top decile).

The 30 countries in the Eurostat database, meanwhile, are divided by income quintiles, not pegged to the global distribution. As shown in Figure 3 in Section 3, the bottom quintile's average household spending in sectors associated with living standards is about the same as for people in the 51st to 75th percentile in low- and middle-income countries. The scenarios we focus on are presented in Table 2.

Table 2 Different upward consumption mobility scenarios and GHG implications

Scenario
A1: Bottom half of global distribution located in non-European LICs/LMICs move upwards to the next lowest quarter of the global distribution ($2.97-8.44 PCE/day)
A2: Bottom 75% of global distribution located in non-European LICs/LMICs move upwards to the next consumption segment of the global distribution ($8.44-23.03 PCE/day); AND bottom European quintile moves to the second lowest quintile
A3: All groups move to the highest consumption segment/ quintile (>$23 PCE/day)

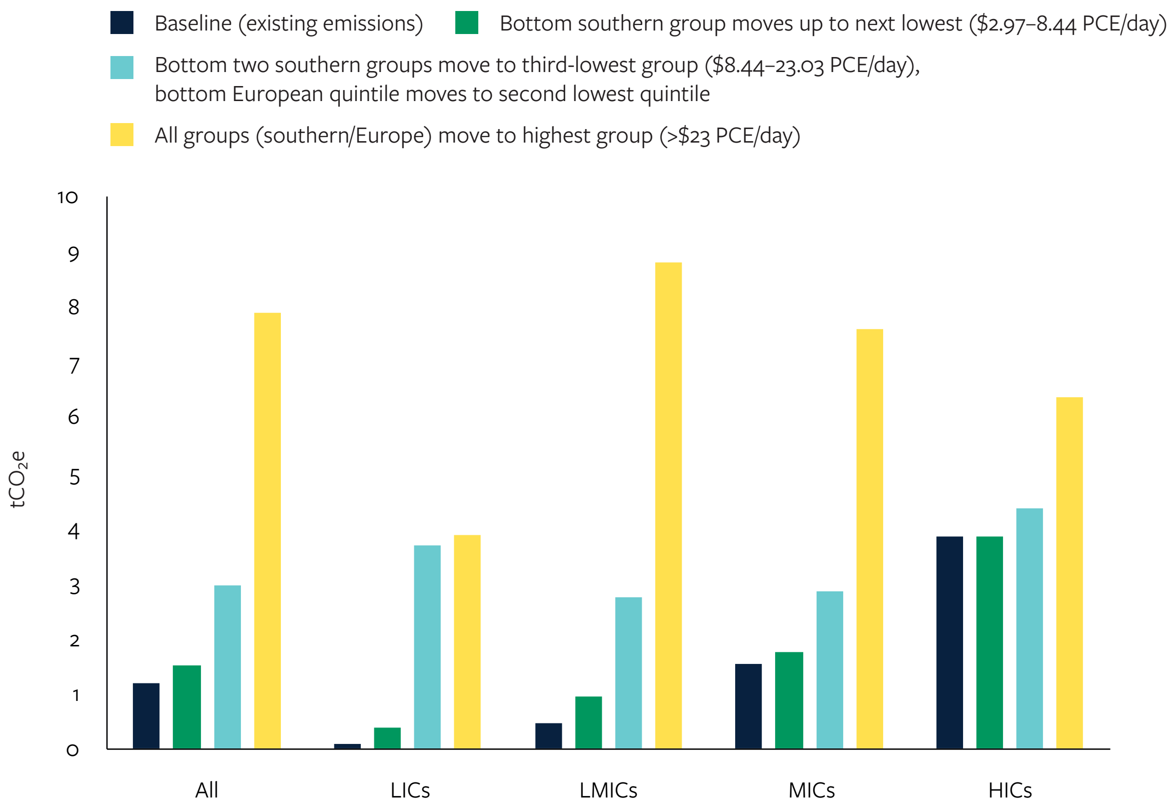
On a per capita basis, Figure 8 shows that the emissions impact of lifting the poorest people (living on less than US$2.97 per day) into the $2.97–8.44 segment (dark blue bars in Figure 8) is negligible across the five sectors aggregated: about 0.33 tCO_2e per person. Even with 2.8 billion people in this category, the aggregate impact on emissions would be relatively small at around 0.94$GtCO_2e$. That is not nothing, but it is considerably less than – for example – the emissions that Japan emitted in 2019, with just 126 million people.[11] Even the impact of shifting people in the bottom two segments in Southern countries to the third segment, while simultaneously moving the bottom quintile in Europe to the second lowest quintile, would cumulatively increase per capita emissions by an average of just 1.73 tCO_2e. By country income group, these figures range from 1.3 tCO_2e among UMICs to 3.6 tCO_2e among LICs.

In other words, even if we raise the living standards of billions of people who now consume too little for their own well-being, their per capita emissions will still be very low and even their aggregate emissions will be quite modest. The continued deprivation of people in poverty won't save the planet from climate change.

In contrast, if everyone consumed as much as the top segment in each set of countries, per capita emissions would increase by an average of 6.71 tCO_2e, taking them from 6.48 to 13.19 tCO_2e per capita. The annual global carbon output would more than double. Those lifestyles are unsustainable, and achieving this level and type of consumption globally would put even the 2°C target far beyond reach.

11 Climate Watch data (from CAIT) show Japan's emissions as 1.13 GtCO2e in 2019 (Climate Watch 2022). Population data for Japan in 2019 are from UN DESA (2022).

Figure 8 Per capita GHG emissions associated with shifts into higher consumption segments.



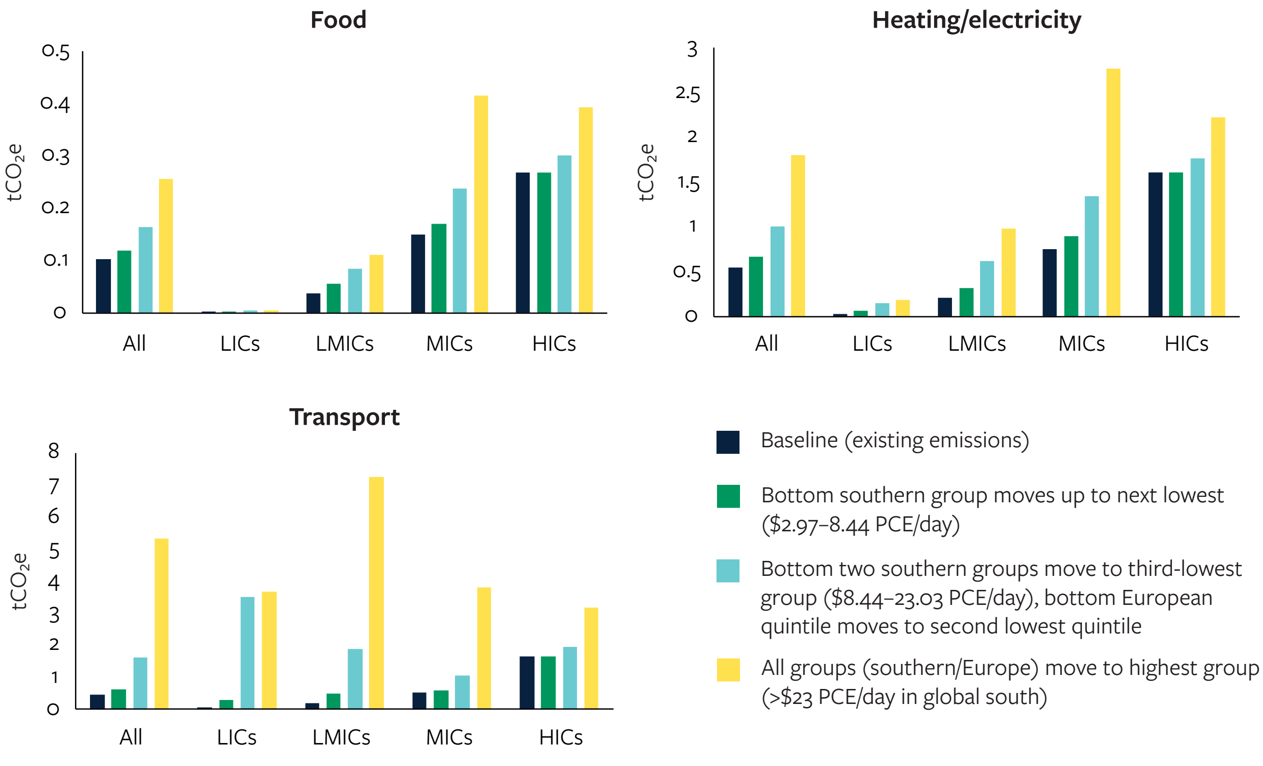
Note: Southern group comprises countries from the Global Consumption Database and refers to the 50 low- and middle-income countries for which data came from that source. European refers to the 27 high-income countries and 3 upper-middle-income countries in the Eurostat database.

The low level of GHG emissions required to improve the living standards of people in and near poverty is also observable across sectors (Figure 9). In light of the discussion in Section 4, the tiny increase in per capita emissions associated with increasing the food consumption of people in the lower segments is particularly noteworthy: 0.02 tCO_2e per year if only the lowest segment is moved up, or by income group equivalent to 0.001 tCO_2e per year amongst LICs up to 0.02 tCO_2e per year among LMICs and UMICs in the Global South. Even moving the bottom two segments in the Global South to the third lowest segment equates to 0.003 tCO_2e per year amongst LICs and up to 0.09 tCO_2e per year amongst Southern UMICs. The corresponding estimates for heating and electricity are 0.11 (to move the lowest segment up in the Global South), or by country income group equivalent to 0.04 tCO_2e per year in LICs, 0.11 tCO_2e per year in LMICs, and 0.14 tCO_2e per year among UMICs in the Global South.

The largest footprint increase would be in the transport sector, where moving the lowest segment up would increase GHG emissions by 0.18 tCO_2e per capita per year, which when disaggregated by country income group equates to 0.25 tCO_2e per year in LICs, 0.31 tCO_2e per year in LMICs, and

0.06 tCO_2e per year in UMICs in the Global South. In this context, it is important to remember that as personal vehicle use is much higher in the Global North than in the Global South, and as more people worldwide enter the middle class, car ownership has surged (Bouton et al., 2015). This means that the living standards of people in lower consumption segments can probably be raised significantly without matching wealthier people's transport spending by instead providing high-quality, reliable and affordable public and active transport infrastructure.

Figure 9 Increase in annual per capita GHG emissions associated with shifts into higher consumption segments, by sector



Note: For food sector emissions (which do not include land use change), we assume an average conversion factor per country across the values of agricultural, residential, and industrial sector emissions

4.2 Climate implications of lowering the consumption ceiling

The second part of our thought experiment is to explore how much GHG emissions could be reduced if wealthier people changed their consumption patterns – particularly by spending less on carbon-intensive options and favouring more sustainable alternatives. We recognise that many people may be unwilling to volunteer to live more frugally for the sake of climate equity. However, we emphasise that people on high incomes often prefer to live in communities with better public transport and walking/cycling infrastructure, to eat healthier diets with fewer animal products, and to enjoy some of the co-benefits associated with cleaner power generation such as predictable energy bills, enhanced energy security and cleaner air. Fortunately, this means that smaller carbon footprints can be achieved without sacrificing living standards. The challenge will be breaking away from path dependencies and economic structures to facilitate individuals to choose lower emission livelihoods without lowering their wellbeing.

Table 3 summarises the scenarios modelled and the results. Scenarios A and B consist of bringing down consumption segments that have high expenditures per capita, high GHG emissions and large populations. Scenarios C and D follow from the observation that the second quintile in Europe have per capita expenditures at a level comparable to the 76th to 90th percentile in LICs and MICs of the Global South.

Table 3 Different consumption equity scenarios and GHG implications among sample countries

Scenario	Outcome in terms of moving poorest people (<US$2.97/day) into next lowest segment ($2.97–8.44/day)
A: HICs/UMICs in Q5 down to Q4 in Europe	Offsets over three times the additional footprint in LICs
B: HICs/UMICs in Q5/ Q4 down to Q3 in Europe	Offsets almost a third of the additional footprint in LICs/LMICs; or Offsets over a quarter of the additional footprint in LICs/LMICs/UMICs
C: HICs/UMICs in Q5/Q4/Q3 down to Q2 in Europe	Offsets more than half of the additional footprint in LICs/LMICs; or Offsets nearly two-fifths of the additional footprint in LICs/LMICs/UMICs
D: Top 10% in LICs/MICs down to 76th–90th percentile	Offsets two-fifths of the additional footprint in LICs/LMICs; or Offsets more than a quarter of the additional footprint in LICs/LMICs/UMICs

Note: Improved well-being refers to people in the lowest global consumption segment (less than US$2.97 per capita per day) to the 51st–75th consumption percentiles (US$2.97–8.44).

Given the large share of transport emissions among wealthier people across country income groups (Figure 4), we also explored the implications for GHG emissions of reducing just the transport sector emissions of wealthier groups. Just by reducing the transport emissions of the top quintile in Europe, we are able to offset over twice the increase in GHG emissions associated with increasing the consumption of people living on less than US$2.97 per day to improve their welfare in LICs. Again, this is a highly simplified, hypothetical calculation. Still, the results of our modelling exercise underscore how development choices made to serve the highest income groups – in this case, the facilitation of private motorised transport rather than investment in mass transit or active transport – have an outsized impact on the remaining carbon budget. Even modest reductions in the share of trips undertaken by private cars with internal combustion engines could carve out enough atmospheric space to improve the lives of billions of people without raising global GHG emissions.

5 Exploring low-carbon opportunities to boost living standards

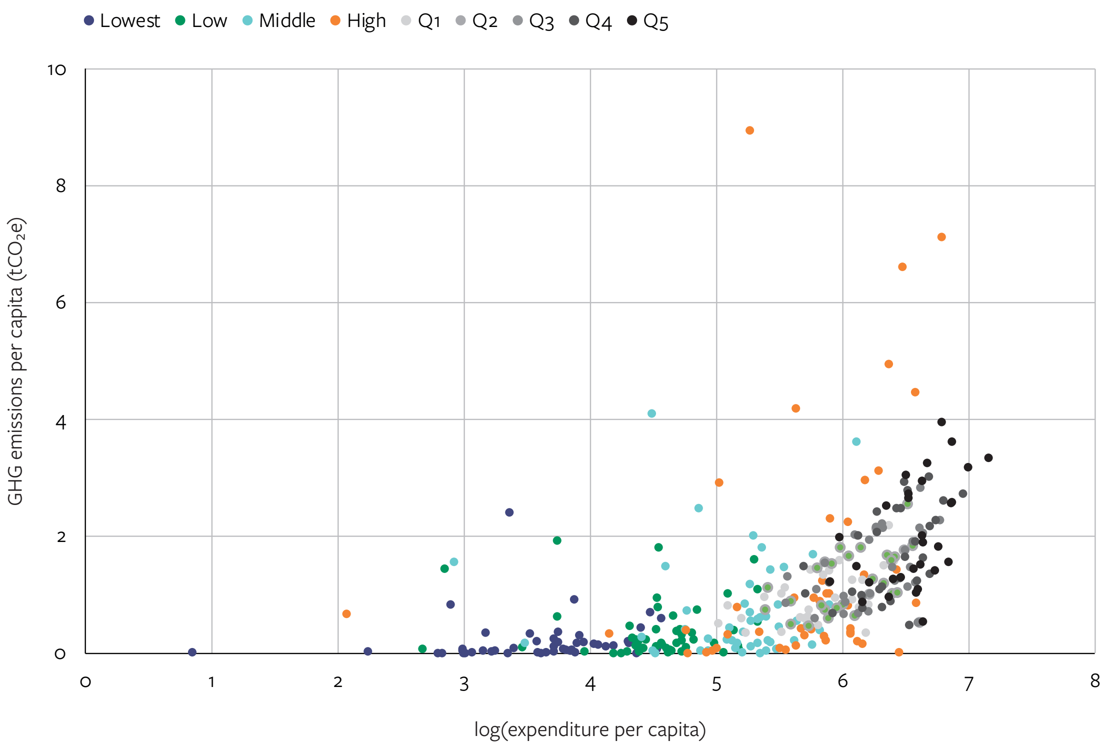
The sectoral differences identified in our analysis point to opportunities to achieve greater human well-being with a smaller climate impact. In this section, we examine two areas where there are big opportunities for decarbonisation, making it possible to achieve (or maintain) a high quality of life without significant GHG emissions: (1) infrastructure – encompassing particularly electricity generation and transport – and (2) food. In each of these areas, there are low-carbon options that deliver comparable outcomes in terms of reliable power, access to goods and services, and nutrition. The relative affordability and viability of those options in specific contexts are shaped partially by exogenous factors such as technological costs, established infrastructure stock and availability of land, but also be endogenous factors such as regulatory environments, planning decisions, acquired capabilities and cultural norms. Both exogenous and endogenous factors will determine whether low-carbon economic trajectories can accelerate poverty reduction or whether they will exacerbate current inequalities.

5.1 Low-carbon infrastructure for high living standards

A reliable, adequate energy supply and transport network is crucial for poverty reduction (Pachauri et al., 2013). Access to reliable power can: improve productivity by enabling households and enterprises to deploy cost-saving technologies (like sewing machines, welding devices or refrigerators); improve public health in part by reducing indoor air pollution; and reduce insecurity and violence, thanks to street and household lighting. Transport provides access to services and economic opportunities, while immobility can trap people in poverty and isolate them socially (see, e.g., Lucas et al., 2016; Wang et al., 2018; Heeckt and Huerta Melchor, 2021). Moreover, electricity and transport are necessary (if not sufficient) to support structural economic transformation, especially industrialisation (Collier and Venables, 2016; Duranton and Venables, 2018).

However, choices around energy and transport infrastructure can lead to very different levels of GHG emissions, in high-, middle- and low-income countries alike. For example, compact, well-connected urban areas, with multi-family housing and strong public transport systems, typically have lower income-adjusted transport emissions than sprawling urban areas with a large share of standalone housing and high levels of private car ownership (Underwood and Fremstad, 2018; Ottelin et al., 2019). Countries that invest in low-carbon power generation – such as hydropower, nuclear, solar or wind – can enjoy all the benefits of electricity without the GHG emissions or air pollution associated with coal- or gas-fired plants, though each of these also has its own risks. The very varied carbon intensities associated with different power generation options helps explain why individuals with comparable expenditure on electricity have such varied per capita emissions associated with this sector (Figure 10). However, most UMICs and HICs have pursued relatively carbon-intensive power and transport systems, explaining the large share of GHG emissions associated with electricity and mobility in higher-income segments of the population (Figure 10).

Figure 10 Per capita annual spending on heating/electricity and associated GHG emissions



These issues are complex, of course. For example, the capital costs of solar and wind power can be higher than those of coal and gas, even if the unit cost of electricity may be lower (IEA, 2021a). Lower-income countries may therefore struggle to mobilise the resources necessary to meet the high upfront investment needs of renewables, not least given persisting consequences of structural adjustment reforms, extractivism and debilitating debt (Bayliss and Pollen, 2021). The financing gap can be compounded by additional costs associated with intermittent renewables (such as energy storage or enhanced transmission and distribution infrastructure), or the uncertainties associated with capital-intensive projects like nuclear and geothermal. At the same time, most low-income countries' grids are unbalanced, and so the need is for more generation. Similarly, in the transport sector, planning, building and operating a metro system is more complex than a highway, even if the former is likely to yield better development outcomes including lower average transport costs, reduced congestion, reduced traffic injuries, and better air quality (Kwan and Hashim, 2016). Countries with weaker implementation capacities may therefore not be able to deliver a mass transit system, even if they recognise its long-term advantages and even in the presence of underlying norms and politics that might favour these outcomes.

Importantly, many countries have policies and spending patterns (often backed by powerful lobbies and climate delay strategies) that favour carbon-intensive patterns of economic and social activity without delivering for the poorest (Lamb et al., 2020). Even as the costs of solar have plummeted (IEA 2022a), countries like Australia and Indonesia have retained policies and subsidies that favour coal-fired power generation (Inayah et al., 2023) while countries like the United Kingdom have retained policies and subsidies that favour gas heating over electrification (UK Climate Change Committee, 2022). Even in low- and middle-income countries where car ownership rates are low, transport spending prioritises road construction instead of mass transit or active transport (Coalition for Urban Transitions, 2019). Reforming climate-unfriendly regulations and reallocating electricity and transport budgets towards renewable energy, public transport and walking/cycling infrastructure could reduce inequality and GHG emissions at the same time (ITF, 2021).

The key point is that there are multiple opportunities to reduce emissions from electricity generation, heating and transport, and that higher-income countries should have the resources and capabilities to realise them. People living in higher-income countries therefore don't have to sacrifice wellbeing to carve out more atmospheric space for human development in lower-income countries. It is possible to slash the carbon footprint of the wealthiest people without meaningfully affecting their living standards.

5.2 Better nutrition with smaller carbon footprints

The food system requires urgent action: food insecurity and acute hunger remain widespread in some parts of the world and for some populations groups, while other populations have high incidence of metabolic disease frequently due to diets associated with high GHG emissions. Dietary change is necessary for global food systems to sustainably meet everyone's nutritional needs (see, e.g., Willett et al., 2019; WHO and FAO, 2019).

A good diet for health varies according to a person's life stage, sex, level of physical activity and metabolism, among other factors. What people actually eat, in turn, depends on their culture, what is available (and affordable) to them, and their personal preferences. Even national dietary guidelines vary dramatically: for a 2,000-calorie diet, for instance, the recommended dairy intake in the US is triple what it is in Thailand; India advises twice the intake of grains as the US and half as much protein (Kovacs et al., 2021). While recognising differences in individual needs and cultural preferences, the literature provides two key insights relevant to this analysis: (1) the diets of people who are now undernourished and/or food-insecure can be greatly improved without jeopardising the planet; and (2) there is significant potential for reducing food-related GHG emissions in high- and middle-income countries without compromising human health – and, in fact, potentially enhancing it.

We focus on three opportunities to reduce emissions associated with global food systems and thereby free up atmospheric space for poverty reduction: switching to more sustainable diets, minimising food waste, and adopting ecologically sound production methods. In line with the analysis put forward in Section 3 of this paper, these opportunities are not equally salient in all parts of the world. Reducing emissions associated with food systems will depend on dietary change primarily in UMICs and HICs, and often among the wealthiest groups in LICs. A shift to more ecologically sound food production methods will depend on action in a relatively small number of major food producers, typically those supplying UMICs and HICs markets. Minimising food waste is – perhaps surprisingly – an increasingly common challenge across countries at all levels of income. The good news is that, with such interventions, it is possible to provide enough food for everyone while keeping global warming below 1.5°C (IPCC, 2022b; Searchinger et al., 2019).

First, switching to more sustainable diets. Within food systems, animal products have by far the most serious impact on the climate. Meat from ruminants (cattle, sheep and goats) produced in intensive farming systems generates 4–6 times more GHG emissions per calorie or gram of protein than dairy products (Searchinger et al., 2019) and over 20 times more per gram of protein than pulses (beans, peas, lentils).[12] In general, the study found, animal products are inefficient sources of calories and protein: as a share of animal feed input, beef only delivers 1% of the calories and 4% of the protein; milk, 7% and 16%, respectively; poultry, 11% and 20%; and eggs, 13% and 25%.

On a global scale, those inefficiencies translate into outsize environmental impacts. One study found that 57% of the roughly 17.3 $GtCO_2e$ in global GHG emissions associated with food production in 2010 corresponded to animal-based foods (including livestock feed), compared with 29% for plant-based foods (Xu et al., 2021). Another found that at least 16.5% of global GHG emissions are attributable to animal agriculture (Twine, 2021).

Many HICs have long had substantial levels of animal protein consumption, with commensurately high historical emissions associated with food production, though consumption levels have differed between socioeconomic groups. Consumers in the US, for example, ate roughly the same amount of beef, pork, and fish and shellfish in 1910 as 2020 – around 40 to 50kg per capita per year. Only their chicken consumption increased from 4.5kg to 27kg (a 540% increase) between 1910 and 2017. By comparison, average annual global meat per capita consumption was 43 kg in 2019 (Christen, 2021). In UMICs, consumption levels have varied significantly between population segments.

However, global meat production has more than quadrupled in the last five decades (OECD and FAO, 2022) and is expected to grow by 15% to meet rising demand – with commensurate impacts on the climate and biodiversity. Consumption is projected to grow about three times as fast in upper-middle-income countries – particularly among the growing middle classes – as in

12 Extensive pastoral livestock systems are a key exception to this: they have been found to have carbon neutral or even carbon positive balances and provide essential ecosystem services, including maintaining biodiversity (Garcia-Dory et al., 2022).

high-income countries, and about four times as fast in lower-middle-income countries (OECD and FAO, 2022). While changing diets within UMICs have a very significant aggregate impact on emissions, it is important to recognise per capita inequalities. At 45.7kg per capita as of 2019, meat consumption in a UMIC like China is still far below Australia (89.6), Canada (70.2), Israel (90.0), New Zealand (75.2), Norway (56.0), and the OECD average (70.1), as well as several UMICs. India's per capita meat consumption was just 3.6kg in 2019 (Whitton et al., 2021).

There is broad agreement that diets that are mainly plant-based are both healthier and more compatible with a climate-safe future (Searchinger et al., 2019; Willett et al., 2019; Kovacs et al., 2021). Moreover, the large differences in meat consumption across similarly wealthy countries make it clear that there is not necessarily a relationship between an animal-based diet and income or living standards. Indeed, in some countries, including Canada and New Zealand, meat demand has declined, though not enough to reach sustainable levels (Whitton et al., 2021), and globally, there has been a notable shift away from red meat and towards poultry (OECD and FAO, 2022). Given that most people in the world's wealthiest countries consume far more protein than they need (Searchinger et al., 2019), a dietary shift in these settings towards whole grains, vegetables and fruit for calories and nutrients, plus legumes, soy and nuts for protein, is a prime opportunity to free up atmospheric space without reducing living standards. For instance, the carbon footprint of the diet recommended by the American government is around 1.4 tonnes CO_2e (Kovacs et al., 2021). Following Thailand's current nutritional guidelines instead would result in a dietary carbon footprint of about 0.7 tonnes CO_2e per year, and India's, 0.3 tonnes (Kovacs et al., 2021).

Second, adopting ecologically sound production methods. Just as there are different ways to generate electricity, there are multiple approaches for growing crops and raising livestock, with different impacts on GHG emissions, land and water use and environmental degradation. For example, rice, one of the world's most important staple crops, is a major source of GHG emissions (Umali-Deininger, 2022; Gupta et al., 2021). Improved production techniques can significantly reduce those emissions as well as water demand. The onus here is on the biggest rice producers, namely China, India, Indonesia, Bangladesh and Viet Nam. The United States, Brazil, the European Union, and China are the world's largest beef producers and will need to downsize their cattle industries while also adopting more environmentally friendly practices. Europe, Russia, the Ukraine and North America are important staple crop producers, but agriculture in these regions relies heavily on energy-intensive inputs, such as fertiliser, and has significant carbon footprints.

With many crops, fertiliser overuse is a driver of GHG emissions and water pollution; more targeted fertiliser use can mitigate those impacts while reducing farmers' costs (Searchinger et al., 2019). Emissions from ruminants can be reduced through improved feeds and methane capture. Overall, emissions from most kinds of meat production have been declining in most of the world, but there are large differences across countries and income groups; for example, poultry production in low- and lower-middle-income countries has about triple the GHG impact per kilo of meat, on average, as in high-income countries (OECD and FAO, 2022). Pork production, on the other hand, is twice as GHG-intensive in high-income countries as in low-income countries, where pigs mainly eat waste.

Climate-smart food production need to be tailored to local conditions: the landscape, the climate, and the social, economic and cultural context. In some areas, it makes sense to combine crop and livestock production for soil fertility, or farming may not be viable at all. As discussed above, extensive pastoralist systems manage to produce meat in carbon-neutral ways, and in other contexts animal proteins provide essential nutrients where they are otherwise not available (WRI, 2019). Poor farmers may not be able to afford seeds for improved crop varieties, or the equipment required to adopt certain practices, and most will need training; both financial and technical assistance are crucial. Countries with ample resources, such the US and European nations, need to move swiftly to achieve this transition, while providing financial and practical support to poorer countries to enable them to seize these opportunities as well.

Third, minimising food waste. Globally, an estimated 25–30% of the food we produce is lost or wasted, accounting for 8–10% of all GHG emissions (Mbow et al., 2019). This includes losses due to inadequate harvesting techniques, poor storage and other problems mainly associated with low- and middle-income countries, but also an astonishing 17% rate of waste on the consumption side – 931 million tonnes globally in 2019 (UNEP 2021).[13] Three-fifths of that waste occurs in households, a quarter in food service, and the rest in retail.

Contrary to long-held assumptions, this is not only a problem in wealthy countries: Looking at 54 countries for which food waste data are available, researchers found household food waste across 28 HICs averaged 79kg per capita per year; across 12 UMICs, 76 kg; and across 10 lower-middle-income countries, 91 kg (data were only available for two low-income countries) (UNEP, 2021).

Indonesia's experience highlights a key risk for food waste associated with inequitable economic growth. Research there has linked the rise in food waste to urbanisation, cultural shifts and class dynamics, among other factors (Soma, 2020b; 2020a). The modernisation of food retail has played a part as well: instead of buying from traditional small-scale vendors and street markets, urban Indonesians now mainly shop in supermarkets, which often incentivise the purchase of larger quantities. Policy interventions are needed to educate consumers and to steer retailers away from unsustainable marketing strategies.

This discussion provides a crucial insight about food consumption and climate equity. The idea is not for people living in UMICs or HICs to halve their spending on or consumption of food, but

13 A small caveat is warranted: these figures include both edible and inedible parts of food items (e.g. bones, peels and seeds). In other words, some food waste is unavoidable, but what people consider inedible varies significantly – from which parts of an animal are eaten, to whether fruits and vegetables are peeled.

to choose the options that are both healthier and more sustainable, building on other work on provisioning systems. Their quality of life may actually improve, while also cutting food system emissions and leaving more of the carbon budget to address urgent development priorities – including reducing food insecurity and malnutrition in lower-income countries.

6 Conclusion

Our analysis suggests that many of the major debates around responsibility for climate change mitigation, and the implications for poverty reduction, are not sufficiently grounded in evidence of the drivers of GHG emissions.

We started from the premise that, by effectively consuming the global carbon budget, industrialised nations and the richest people in MICs and LICs have left little space for the rest of the world to develop and for people in and near poverty to raise their living standards. Our quantitative analysis, based on household survey and energy data for 56 countries in the Global South and 30 in Europe, showed large disparities in per capita household consumption and associated GHG emissions. It highlighted that even lower-income segments of the population in industrialised UMICs and HICs typically have very large per capita carbon footprints compared to their counterparts in LICs and LMICs. Our findings are especially striking given that European countries, on average, have lower per capita emissions than those of other Western nations (such as the US, Canada and Australia) or of some other high-income groups (such as the countries in the Persian Gulf). Our results may therefore understate global carbon inequalities. However, they also expose disparities within countries – in particular, the very high consumption and emissions of the richest people in low- and middle-income countries.

A deeper dive into the consumption of electricity and heating, household appliances and services, transport, food and health by different income segments underscored how increased expenditure in select sectors corresponds closely to an increased carbon footprint. Increased spending on electricity/heating, food and transport in particular typically corresponds with higher levels of GHG emissions. However, there is great variation among countries at comparable levels of income, revealing that it is possible for citizens to enjoy a more reliable power supply, more nutritious diet or enhanced access to goods and services without a commensurate increase in their carbon footprint. However, the carbon intensity of individual's electricity and transport in particular is largely out of their personal control and depends on national choices around (for example) investments in solar, wind or geothermal rather than coal and gas, or investments in railways, bus networks and cycle lanes rather than roads and parking spaces. The challenge will also be breaking away from path dependencies and economic structures to facilitate individuals to choose lower-emission livelihoods while maintaining living standards.

With the global carbon budget nearing exhaustion, poverty on the rise, and inequalities deepening, we cannot afford to keep ignoring the unmet challenge of climate equity. There is a growing recognition that without greater equity, the global climate agenda will be unlikely to succeed.[14] This paper contributes to that urgent policy discourse by encouraging a renewed attention to the choices of higher-income countries and individuals, and by underscoring the relatively small emissions associated with improving the living standards of the poorest. In the future, a more comprehensive analysis, using more recent data for more countries, including Australia, Canada, China, Japan, Russia, Saudi Arabia, South Korea, and the US could provide more detailed and actionable results.

What do our findings mean in practice?

First, upper-middle and high-income countries need to raise the ambition of their Nationally Determined Contributions in line with their 'fair share' of effort. In the introduction, we cited research showing that the world's largest and wealthiest emitters are setting emission reduction targets based on a self-interested definition of equity (and even then, falling short). These decisions exacerbate longstanding carbon inequalities. Yet our analysis underscores how there are large opportunities for higher-income countries and individuals to cut emissions without necessarily affecting their quality of life, particularly through interventions in the electricity/heating, transport and food sectors. By tackling key drivers of emissions such as car dependency or high consumption of animal protein, they could accelerate their own decarbonisation and boost living standards at home, while leaving more of the remaining carbon budget for lower-income countries and individuals to improve their quality of life.

The specific policies and investments to achieve these goals will vary from country to country, but may include:

- reforming energy and agricultural subsidy regimes that favour unsustainable production and consumption
- shifting national energy and transport budgets to support clean power generation, mass transit and active transport
- using quotas and targets, renewable portfolio standards, feed-in tariffs, tax exemptions and targeted auctions with long-term contracts, to incentivise private investment in renewable electricity generation
- establishing integrated spatial and infrastructure investment plans that can underpin a pipeline of climate-safe, bankable projects in transport sectors
- reforming national land use and building regulations to favour denser, mixed-use urban development
- reforming national dietary guidelines and – where applicable – procurement policies to favour plant-based diets.

14 See, for example, the Climate Action Tracker's 'fair share' estimates; the IPCC's emphasis on accelerating the climate transition while supporting continued development (Denton et al., 2022); discussions around '1.5-degree lifestyles' (Akenji et al., 2021).

The low-carbon measures available to UMICs and HICs, and their prospective impacts on incomes and living standards, are documented in detailed sectoral analyses and reviews, such as those developed by the IPCC (Clarke et al., 2022; Nabuurs et al., 2022; Jaramillo et al., 2022), the Energy Transitions Commission (2018; 2021), the Food and Agriculture Organisation (FAO et al., 2021), the Coalition for Urban Transitions (2019); and the Food and Land Use Coalition (2021).

Second, there needs to be a renewed global effort to improve the living standards for the poorest 50% of the global population, who mostly live in low- and lower-middle income countries. People living on less than $2.97 a day frequently lack access to adequate, nutritious food, reliable, modern energy, adequate healthcare services, and the other fundamentals for a decent quality of life. Indeed, many of those in the next income segment (less than $8.44 a day) may also have levels of consumption that are below those envisioned in the Sustainable Development Goals and other global targets. A rising number of people now fall into this category, as the impacts of Covid-19 and soaring food and energy prices are pushing people back into extreme poverty (World Bank, 2022). Our analysis makes it clear that significantly increasing the consumption of these more than 4 billion people would not meaningfully jeopardise the global carbon budget remaining for 1.5°C or 2°C, relative to the outsized emissions of higher-income countries and individuals.

Moreover, there are clearly options available to enhance people's diets, mobility and energy access while producing minimal additional GHGs. Plant-based diets, active and mass transit, and renewable power generation can all meet human needs in relatively low-carbon ways in lower-income countries as well as higher-income countries. However, in some cases these low-carbon measures may entail higher upfront costs and/or more sophisticated implementation capabilities as detailed in Section 5. In these instances, international support is critical for overcoming barriers to low-carbon development.

Third, higher-income countries need to deliver more generous, integrated support for climate-compatible development in lower-income countries. The climate accords outline the need for developed countries to provide climate finance, technology transfer and capacity building to enable low- and middle-income countries to mitigate and adapt to climate change. However, such support has fallen woefully short of low- and middle-income countries' needs. The failure is most starkly encapsulated in developed countries' failure to fulfil their pledge of providing and mobilising $100 billion a year from 2020, even though that target that is widely recognised to be inadequate (see, e.g., Haegeli and Garbers, 2022; Global Commission on the Economy and Climate, 2014). New shocks and stresses have widened the financing gap, including the Covid-19 pandemic and rampant inflation fuelled by the Russia-Ukraine war. It is little surprise that calls for reform to the global development and climate finance architecture are now coming from all sides. The most visible and charismatic figure calling for change is Prime Minister Mia Mottley of Barbados, but there are also demands for reform from climate-vulnerable countries (the V20), the G7 countries (Germany, France, the US) and the G20 via its Eminent Persons' Group on Global Financial Governance and Independent Review of Capital

Adequacy Frameworks (Prizzon and Léautier, 2021). If higher-income countries are serious about both poverty reduction and limiting warming, they will need to step up to support lower-income countries to achieve both goals.

Lastly, we recognise that, though our analysis largely relied on consumption data as a proxy for living standards, there is a wide array of ideas and perspectives that can enrich our understanding of a decent life. In the Global North, for instance, the Wellbeing Economy Governments (WEGo) partners are working together to develop innovative and holistic approaches to human well-being.[15] Bolivia's concept of *Buen Vivir* ('living well') aims for 'harmony and balance' with the cycles of Earth, life and history.[16] And Bhutan's Gross National Happiness Index measures well-being across nine domains, including living standards, but also environment, culture and community vitality, among others (GNH Centre Bhutan, 2022). Each of these different frameworks suggest there are many opportunities to reduce one's environmental footprint without undermining human well-being. Indeed, well-designed policies and investments could contribute to multiple objectives at once: healthier and more productive people, more equitable societies, and a safer climate. What matters in the end is not how much people spend, but that they are able to thrive. By prioritising equity, we can ensure we have the atmospheric space to make that a reality for all.

15 See https://weall.org/wego.
16 See www.cancilleria.gob.bo/webmre/node/1231 (in Spanish).

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Appendix 1 Country coverage

Low-income	Lower-middle-income	Upper-middle-income	High-income
Benin	Bangladesh	Albania	Austria
Ethiopia	Bolivia	Armenia	Belgium
Mozambique	Cambodia	Azerbaijan	Croatia
Nepal	Cameroon	Belarus	Cyprus
Tanzania	Cote d'Ivoire	Brazil	Czech Republic
Togo	Egypt	Bulgaria	Denmark
Rwanda	El Salvador	China	Estonia
Guinea	Ghana	Colombia	Finland
Malawi	Honduras	Guatemala	France
Burkina Faso	India	Jamaica	Germany
Uganda	Indonesia	Jordan	Greece
Madagascar	Kenya	Kazakhstan	Hungary
	Kyrgyzstan	Mauritius	Ireland
	Lao PDR	Mexico	Italy
	Mongolia	Namibia	Latvia
	Morocco	Paraguay	Lithuania
	Nicaragua	Peru	Luxembourg
	Nigeria	Romania	Malta
	Pakistan	Russia	Netherlands
	Philippines	South Africa	Norway
	Senegal	Sri Lanka	Poland
	Ukraine	Thailand	Portugal
	Viet Nam	Türkiye	Slovakia
	Zambia		Slovenia
			Spain
			Sweden
			United Kingdom

Notes: The dataset did not include GHG emissions intensity data for Rwanda, Guinea, Malawi, Burkina Faso, Uganda and Madagascar, so they are not included in the GHG graphs. Bulgaria, Romania and Türkiye are part of the Eurostat dataset, alongside the HICs.