Commentary

Carbon Inequality: Resolving Contradictory Results From Two Different Approaches

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Two approaches to assigning responsibility for global carbon emissions provide complementary insights. Individual-level analyses highlight the disproportionate emissions of the wealthy, country-level ones the growing importance of emissions from middle-income countries. We propose the concept of reasonable vs. excessive consumption as a way to integrate these approaches into a synergic and less divisive perspective about how to address the current climate challenge. Commonly advocated efficiency improvements should be supplemented by cutting excessive consumption and acknowledging the role of population increase on sustainability goals in both high-income and poorer nations.*Keywords:*** **climate justice, overconsumption, emission disparity, population**

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1. Introduction

To formulate fair and effective policies to reduce carbon emissions, it is crucial to identify their main drivers. Unfortunately, some results provided in the scientific literature and activist reporting can end up confusing rather than clarifying the issue and possibly hinder the process of reaching consensus on the best policies to address them.

On the one hand, several studies emphasize the disproportionate emissions generated by the wealthy[1] [2]. An often-quoted report, commissioned by Oxfam and carried out by the Stockholm Environment Institute, claims that the richest 10% of the world population (about 800 million people) is responsible for 50% of global greenhouse-gas (GHG) emissions, while the poorest 50% (about 4 billion people) only

accounts for 8% of GHG emissions[3]. While this report was not peer-reviewed, the result is confirmed by scholarly work. In a study published in *Nature Sustainability*, Chancel shows that, between 1990 and 2019, the bottom 50% by income of the world population emitted, on average, 1.4 t of CO_2 per person and year (leading to 11.5% of global emissions), the middle 40% emitted 6.1 t (40.5%), and the top 10% emitted 28.7 t (48%)[2]. Chancel also finds that the top 1% emitted, on average, 101 t CO_2 per person and year, 16.9% of the total, showing how just 80 million wealthy individuals had an impact larger than the poorest half of the human population.

On the other hand, the most recent IPCC assessment report attributes substantial emission increases to the growth of a global consumer class, numbering several billions and able to generate substantial carbon emissions due to newfound prosperity[4]. According to the same report, population growth is one of the main drivers of increased global GHG emissions. This is confirmed by a recent study showing that this factor drove 40.2% of global carbon emission increases over the last three decades[5]. Moreover, the same study found that middle-income countries were the main responsible for global emission increases in the last 30 years, which is also consistent with the analysis of the global value chain by Meng et al.[6]. Per capita emissions declined in high-income countries during this period, so the slight increase in their total emissions was actually caused by population growth.

To sum up, some voices claim that a relatively small, wealthy elite is responsible for most global GHG emissions. They also consider the role of population growth negligible, arguing that most population growth occurs in poor countries with low per capita emissions. Other researches, however, indicate a variety of multiple and interconnected factors, including population growth, as main drivers of global carbon emissions, along with increased wealth.

In this work, we show that these outcomes derive from two different yet complementary approaches and, when correctly interpreted, the apparent contradiction vanishes. We integrate both approaches into a comprehensive one, which has the potential of going beyond divisive perspectives and addressing climate change in a more effective way.

2. Individual- vs country-level approaches

The studies above crucially differ in their level of analysis. The ones emphasizing the role of inequality and economic disparities, such as[2] and[3], usually take an individual-level approach; the ones resulting in a multiplicity of factors affecting climate change, such as[4][5][6], take a country-level approach. Both

compare carbon emissions from different income groups but use different data to define them: estimates of individual income (usually at the household level) vs. country-level Gross Domestic Product (GDP) statistics. As a consequence, the expression “income group” takes a different meaning in the two approaches: people with a given income regardless of where they live, in the former, populations living in countries with a given per capita GDP, in the latter. For instance, adopting an individual-level approach, “the rich” are high-income people living in any of the world’s countries, while adopting a country-level approach “the rich” are people living in high-income countries. While there is some overlap between these two groups, they remain conceptually and practically different.

Such a difference is highlighted in Figure 1, which compares the outcome of two different analyses. Panel A shows Chancel’s individual-based approach, Panel B shows our analysis using country-level data from the World Bank database[7]. To perform this analysis, we first ranked countries based on their per capita GDP, then created groups using the same splits as in[2] in order to facilitate the comparison. Thus in panel B, “top 10%” includes the first countries in the ranking whose combined population covers 10% of global population, “middle 40%” includes the next countries in the ranking whose combined population covers 40% of global population and “bottom 50%” includes all the other countries.

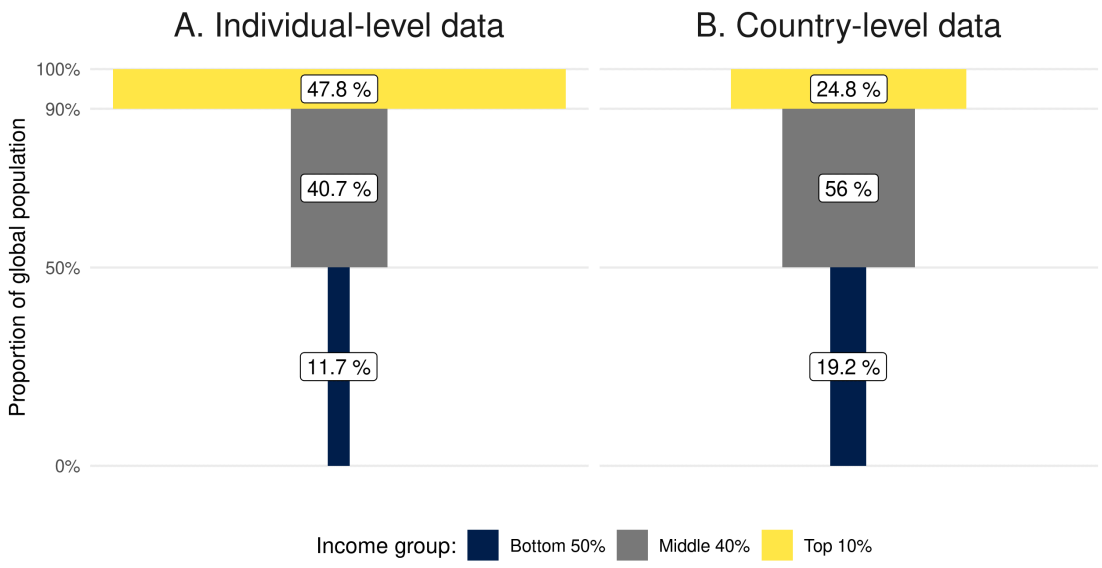

Figure 1. Distribution of 2019 emissions by income group defined using an individual-level approach (Panel A) and a country-based one (Panel B). Areas in the figure are proportional to emissions.

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These different ways to compute emissions result in relatively similar global emission estimates. The country-level approach leads to a total emission estimate of 48.1 Gt CO_2-equivalent for 2019, while the individual-level one leads to 46.3 Gt CO_2-equivalent. Nevertheless, the distribution of these emissions is significantly different (Fig. 1). The reason for such contrasting results is that economic disparities exist not only *between* countries but also *within* countries, as rich people do not only live in high-income but in middle-income and even low-income ones as well. Likewise, poor people also exist outside low-income countries. Actually, while between-country economic disparities have decreased in the last decades, within-country ones have become increasingly relevant today[2][8].

Besides producing different outcomes, these two approaches have different advantages and disadvantages, as well as technical strengths and weaknesses, which must be carefully considered when dealing with the results of the analyses.

2.1. Advantages and limits of the country-based approach

This approach is probably the most common one for studies linking development and GHG emissions[4][5][9]. It's main advantages rely on the fact that it is based on well established and regularly updated data from internationally recognized sources. For instance, the World Bank data used in the analysis shown in the B Panel of Fig. 1 include consolidated emission for the six main GHGs from most major sources and sinks. In addition, the country level is the one where most political decisions are actually made, which makes research results easier to translate into policy-making.

This comes at the cost of losing focus on what happens within each country, most noticeably on income differences. This may be especially problematic since the last 20–30 years have seen a parallel decrease in between-country and increase in within-country income inequality[8], with within-country differences now accounting for almost two thirds of global emissions inequality according to[2].

2.2. Advantages and limits of the individual-based approach

Individual-level data usually derive from household consumption surveys and require extensive processing to estimate the related GHG emissions. For instance, Chancel[2] uses consumption self-reported expenditures from the World Bank's Global Consumption Database[10], which are then then transformed into emissions using an Environmental Multi-Regional Input-Output (EMRIO) model.

The main advantage of using this kind of data is that they allow a consumption-based perspective (also called *environmental or carbon footprint*), where the environmental cost of the consumption of a given good or service is attributed to the individual who actually benefit from it, not to its producer[11]. In addition, they highlight within-country income disparities, which means that high-income emitters in middle and low-income countries no longer remain hidden behind moderate national averages.

One limit of this approach is the poor reliability of household-survey data[12]. Moreover, the robustness of input-output tables and other models needed to translate them into GHG emissions is sometimes questioned[13], especially because of their reliance on several simplifying assumptions, e.g. fixed production structures and proportional relationships between inputs and outputs[14][15]. This means that its outcomes have higher uncertainty and should be taken with care.

Moreover, in the framework developed in[2] and also used in the Oxfam report[3], individual emissions are generated by three different factors: private consumption, public spending, and investments. While the attribution of the environmental cost of private consumption to the consumer is straightforward, the other two are problematic.

Emissions from public spending are linked to the provision of infrastructures and services of public interest. It is not always evident how to attribute the related emissions to individuals, as specific groups may differently benefit from specific infrastructures or services, but a reasonable strategy is to equally split them among all residents in a given country. This was the baseline strategy used by Chancel, although he also tried alternative splits, which did not drastically change the final picture.

Investments have two sides. From the point of view of the investor, they are mainly a way to produce a rent from existing financial capital. However, when adopting the point of view of the investee — usually companies or countries — the picture becomes more complicated. Countries use the invested capital to provide infrastructure and services to citizens. Companies use it to buy equipment and services to produce goods sold on the market, which requires consumers willing to buy them in order for the investment to become profitable. Chancel attributes the whole environmental cost of investments to investors[2], which is a simple and practical way of accounting for it but hides the fact that investments are ultimately driven by the final demand for goods and services.

An alternative accounting is to attribute the emissions from investments to the individuals who actually benefit from them. This would also be more consistent with the consumption-based perspective. Since investments represent a large part of the emissions of the richest people, such an alternative attribution

would lead to a very different outcome from the one found by Oxfam and Chancel and more similar to the country-level approach.

In short, while the individual-level approach has the advantage of taking a consumption-based perspective, it presents significant methodological challenges and its outcomes are strongly dependent on several debatable assumptions.

3. Risks of misinterpretations and simplistic conclusions

Despite their different perspectives, the results of the individual-level approach are sometimes misinterpreted as providing country-level information. For instance, the opening of Oxfam's report states: "The richest people, corporations *and countries* are destroying the world with their huge carbon emissions"[3].

Similar arguments, sometimes combined with a poor knowledge of the technical background of the analyses, may lead to an oversimplified debate about how to reduce carbon emissions. The conclusions emerging from this debate create the illusion of easy solutions, without the need to take a more comprehensive approach. Two of the most common conclusions are presented below.

3.1. "Cutting consumption of the wealthy is the solution"

On any plausible account, the wealthy do generate a large share of GHG emissions. This suggests that cutting their consumption will lead to a significant reduction in GHG. However, the greater percentage of wealthy people's emissions is not due to their consumption but to their investments; the wealthier they are, the higher the percentage[2]. When focusing on consumption alone, research shows that the carbon footprint is proportional or even less than proportional to income[16][17]. This is also in line with Chancel's data, showing that — when investments are excluded — the emissions of the top 10% are lower than the emissions of the middle 40%, hence not confirming the champagne-coupe distribution.

Emissions linked to investments, as explained in Section 2.2, are attributed to the investors but are ultimately driven by the larger public consuming the final goods and services produced through investments. As a consequence, even if the richest stopped investing, other investors might exploit the existing demand for those goods and services. Shifting investments from wealthier to poorer individuals may make societies more equal but would not necessarily lower overall GHG emissions.

Conversely, cutting investments, as well as cutting excessive consumption of wealthy people, would possibly lead to a reduction in GHG emissions but also to higher prices and reduced job opportunities, with consequent impoverishment of the general population.

This does not mean that wealthy people do not have to cut their emissions (see Section 4.1), but shows that: *(i)* GHG emissions from consumption alone are more evenly distributed than generally thought, implying that the emission reduction achievable by cutting the top 10% consumption is more limited than generally expected and possibly insufficient; *(ii)* emissions of wealthy people are deeply interconnected with the emissions of billions of other people and therefore cutting the emissions of the richest may imply adverse externalities on others from lower income groups.

3.2. "Population growth is not relevant"

Oxfam's champagne-coupe graph is often used to support the argument that population growth is irrelevant for climate change, since population is mainly growing in poor countries, while carbon emissions mainly come from rich countries where population does not grow. However, this argument only holds assuming that humanity's richest 10% all live in the world's richest countries, which is incorrect and not even supported by considerations included in the Oxfam report itself[3].

Our country-level analysis corrects this picture. The 10% of people living in the richest countries are not responsible for half of global emissions, but for about one fourth (see fig. 1, panel B). They do have higher average individual emissions than citizens of poorer countries, but the difference is less extreme and the champagne coupe shape of the graph is lost.

Crucially, most current global emissions (56%) are produced by countries in the "middle 40%" group (Fig. 2), a set of 77 countries that includes the entire World Bank's upper middle-income group and encompasses part of high-income and lower middle-income countries as well (Fig. 2). Nearly a quarter of these 77 countries have fertility rates above replacement rate and this group's population growth is significant, amounting to more than 182 million people in the last 10 years, fully 24% of global population growth[7].

This shows that Oxfam's report does not actually support the argument above. Moreover, as the IPCC notes in its *Sixth Assessment Report*, "modest population increases in wealthy countries may have a similar impact on emissions as high population increases in regions with low per capita emission levels"[4].

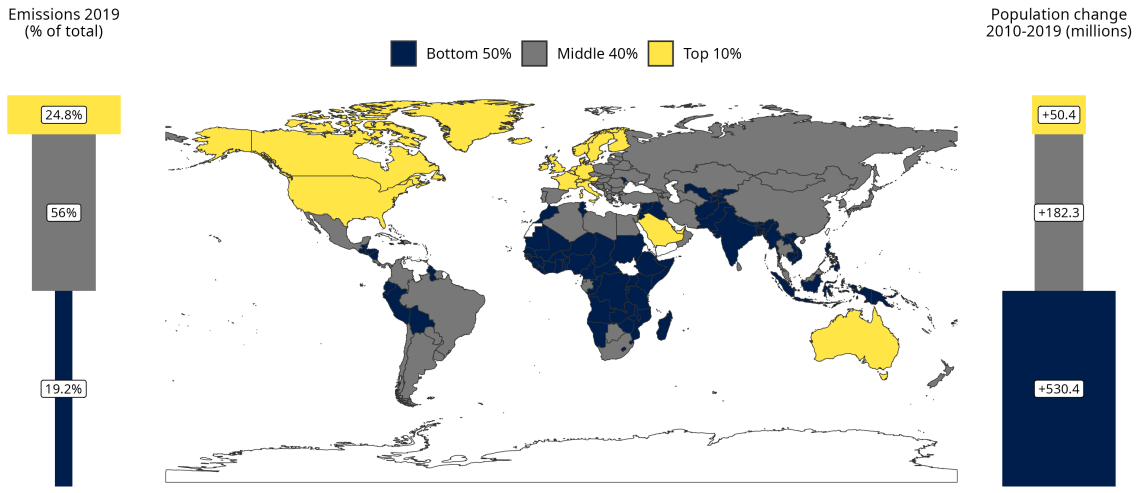

Figure 2. Geographical distribution of country income groups. The left panel reproduces the results presented in Figure 1B. The right one shows total population changes per group in the 2010–2019 period.

4. A more comprehensive approach

To reduce risky misinterpretations and better highlight possible climate mitigation options, we propose a shift from *who* is consuming to *what* is being consumed, distinguishing between *reasonable* and *excessive* consumption.

Reasonable consumption can be seen as consumption associated with maintaining decent living standards, which are defined as the set of goods and services needed to support a level of human well-being consistent with the UN Sustainable Development Goals[18][19]. Excessive consumption would then be consumption exceeding this level. In practice, a division between reasonable and excessive consumption is difficult, beyond extreme cases such as private jets or luxury yachts. Deciding what consumption is excessive and what is not is somewhat subjective and would require collective agreement[20].

Despite this undeniable challenge, such a division looks like a more promising way to identify the necessary lifestyle changes to reduce GHG emissions. Furthermore, it is less likely to create divisions among opposing social groups or nations, a factor that has historically hindered effective climate negotiations and policies[21][22].

4.1. Cutting excessive consumption: part of the solution

While cutting reasonable consumption is neither realistic nor in line with the SDGs, excessive consumption can and should be cut, regardless of who is doing it. Significantly cutting excessive consumption, for instance through the implementation of progressive carbon taxes, is crucial[1]. This both because it represents a significant percentage of the total and because most people will not sacrifice to cut their own emissions without a positive example from the world's top consumers.

Nevertheless, middle-income people are responsible for a comparable, if not larger proportion of consumption-related emissions (see Sec. 3.1) and they have to cut their excessive consumption too.

Meanwhile, many of the world's poorest people should likely increase their consumption to meet the SDGs. This will lead to a more fair and equitable world[23][24], but make overall GHG reduction even more challenging.

Given these limits on possible consumption cuts, a logical question is whether cutting excessive consumption is enough to meet the Paris agreement's goals or not. Moreover, it is difficult to convince people to significantly cut their consumption and, where successful, it will have real costs and externalities (see Sec. 3.1, 4.1). This suggests that instead of exclusively focusing on consumption, we should adopt a more integrated approach, taking into account also other emission drivers[5][25][26][27].

4.2. Reducing human numbers: part of the solution

Population growth is recognized as one of the main drivers of GHG emissions increase: as the IPCC's Sixth Assessment Report states "globally, GDP per capita and population growth remained the strongest drivers of CO_2 emissions from fossil fuel combustion in the last decade"[4]. As long as the population keeps growing, we have to expect a growing demand for goods and services. As long as there is a demand, someone will invest to satisfy it. This will result in an increase in investments, represent the largest part of the GHG emissions of the wealthy (see Sec. 2.2).

In addition, there is overwhelming evidence that today's population of 8 billion people, mostly living with the benefits of industrial civilization, is already unsustainable[26][28][29]. Several scientific studies show that policies to limit population growth have significant potential to reduce GHG emissions and would often do so with less cost and greater co-benefits than other options[28][30]. For example,[31] found that if the world population followed a low rather than a medium growth path scenario, global emissions would be reduced 15% by 2050 and 40% by 2100.

Policies aiming to reduce and possibly reverse population growth should hence be part of the solution[32], clearly avoiding coercion. It is worth noticing that, unlike the deplorable one-child policy in China, there are many examples of effective and voluntary family planning programs, which did not violate but enhanced human rights and led to improvements in life quality for women and children[33][34].

5. Conclusion

While carbon inequality is an undeniable fact, the idea that climate change can be solved by only cutting the emissions of wealthy people is an oversimplification that neglects other undeniable facts, such as the deep interconnections between individual emissions, the large and increasing consumption-related emissions of the middle class, and the role of population growth in driving growing emissions. While cutting the consumption of the richest is both necessary and ethically desirable, the search for climate culprits risks blinding us to a simple fact: a significant part of emissions is driven by a growing population demanding more and more.

We are in ecological overshoot and there is no viable option but to return within reasonable planetary boundaries[26][35][36]. Simultaneously addressing all emission drivers, including population growth, and cooperating across economic and political divisions look like more promising ways to mitigate climate change and achieve sustainability.

Statements and Declarations

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