CLIMATE INEQUALITY REPORT 2023

Fair taxes for a sustainable future in the Global South

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Credits

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Executive Summary

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WHY THIS REPORT?

The climate crisis has begun to disrupt human societies by severely affecting the very foundations of human livelihood and social organisation. Climate impacts are not equally distributed across the world: on average, low- and middle-income countries suffer greater impacts than their richer counterparts. At the same time, the climate crisis is also marked by significant inequalities within countries. Recent research reveals a high concentration of global greenhouse gas emissions among a relatively small fraction of the population, living in emerging and rich countries. In addition, vulnerability to numerous climate impacts is strongly linked to income and wealth, not just between countries but also within them.

The aim of this report is twofold. It endeavours first to shed light on these various dimensions of climate inequality in a systematic and detailed analysis, focusing on low- and middle-income countries in particular. It then builds on these insights, together with additional empirical work and interviews with experts, to suggest pathways to development cooperation, and tax and social policies that tackle climate inequalities at their core.

OUR KEY FINDINGS

All individuals contribute to emissions, but not in the same way. The top 10% of global carbon emitters generate almost half of all greenhouse gas emissions. Thus, in addition to an obvious equity concern, there appears to be an efficiency question at stake. The marginal effort required to achieve the same emission reductions might be significantly lower for high-emitting groups, thereby creating a strong incentive for policies targeted at this group. The comparison of the global bottom 50%, middle 40% and top 10% in terms of losses, emissions and capacity to finance global climate action provides a striking snapshot of climate inequalities and a reasonable guide to identify the key contributors to the funding of climate inequality reduction policies (**Figure A**).

Better understanding how groups may win and lose from the energy transition is key to accelerating it. It is also necessary to draw policy conclusions from the fact that the top emitters are likely to be relatively well protected from the adverse consequences of climate change. Hence, their incentives to reduce emissions are not necessarily aligned with the damage those emissions cause. This holds at the international level, as well as within countries. Quantifying inequalities in carbon emissions and exposure to damages allows to be more explicit about these issues and can help facilitate effective climate policies, as well as public debate on these important matters.

Carbon inequalities within countries now appear to be greater than carbon inequalities between countries. The consumption and investment patterns of a relatively small group of the population directly or indirectly contribute disproportionately to greenhouse gases. While cross-country emission inequalities remain sizeable, overall inequality in global emissions is now mostly explained by within-country inequalities by some indicators.

Ending global poverty need not overshoot global carbon budgets. Recent research contradicts the idea that ending global poverty would eat up most of the remaining global carbon budget to meet the Paris targets. Lifting large numbers of people out of poverty need not have a large negative effect on climate change mitigation. The carbon budgets required to eradicate poverty remain relatively limited compared with global top emitters' footprints. With well designed redistribution and climate policies, the impacts of poverty alleviation on overall emissions can be further reduced.

Climate change contributes to economic and material deprivation in myriad ways, now well documented. It aggravates low agricultural productivity in poorer countries, as well as water scarcity and security. Heat waves have significant impacts on mortality, particularly in vulnerable urban centres. Tropical cyclones and floods will continue to displace millions of people, mostly in low-income countries, and rising sea levels will make large swaths of coastal land inhabitable. While such events will affect regions as a whole, studies point to a strong socio-economic relationship between exposure (and especially vulnerability) and current living conditions, whereby the worst off are more affected than the rest. The wide set of already visible climate change impacts reveal that, when it comes to mitigation, every fraction of a degree matters. It follows that every tonne of carbon matters as much as every dollar of adaptation funding.

As a direct consequence, all governments need to reconsider their mitigation targets, and especially the historical emitters, the list of which should include large emerging economies, as emissions continue to rise.

OUR RECOMMENDATIONS FOR DONORS AND GOVERNMENTS

1. Significant resources should be invested in the production and collection of climate inequality statistics in all countries. The current state of public statistics on the matter remains very incomplete and lags behind the publication of other economic indicators.

2. Step-up efforts to honour climate finance pledges and further increase international development aid. The decision made at Sharm el-Sheikh COP 27 to create a Loss and Damage Fund is a step in the right direction. Yet the timeline for operationalising the fund is quite short (COP28), and politically sensitive questions remain on who benefits and who pays. Adaptation funding flows still pale in comparison with adaptation funding needs, making new funding mechanisms such as a "1.5 percent-for-1.5 degree" wealth tax necessary (**Figure E**).

3. International transfers will not be sufficient to address climate inequalities however. Profound transformations of international and national tax regimes will be necessary to increase the overall progressivity and returns of taxes and ensure that mitigation and adaptation efforts are shared equitably across the population.

- **Strengthen the position of LMICs in an overhaul of multinational taxation.** It has been found that LMICs would not benefit much from the recently proposed multinational taxation rules (discussed under the aegis of the OECD). Yet, global profits that are currently undertaxed could become a sustainable revenue source for LMICs (**Figure F**).
- **Increase the progressivity of national tax systems in particular in LMICs.** Many countries still lack progressive capital income taxes, top inheritance taxes or progressive wealth taxes, which could generate significant revenues to support vulnerable groups without hurting economic growth or the middle class. Greater efforts, including more funding from donors and national governments, should be made to help low and middle income countries modernise their tax systems (for rich countries, these efforts often start at home).
- **Harvest the low-hanging fruit**. Certain measures (e.g. taxes on excess profits) within relatively easy reach could help to fund adaptation and mitigation without hurting low- and middle-income groups disproportionately.

4. Earning more, but also spending better by learning from successful experiences

abroad. The gradual removal of fossil fuel subsidies in a country like Indonesia suggests that when accompanied by directed social reforms for the population as a whole (e.g. health insurance) and specific assistance to low-income households, potential fuel price hikes do not necessarily result in welfare losses for the poor. Targeted cash transfers are another example of a robust instrument for reducing inequalities in the immediate impacts of climate-related disasters. They have also been shown to be an effective measure for climate-resilient development.

5. Systematically investigate both intended and unintended consequences of climate and development policy across income and wealth groups. This report provides an inequality-check matrix for development cooperation and national policies (**Figure G**), which can help policymakers, project developers or civil society actors to formulate their own distributional impact indicators and evaluate policies.

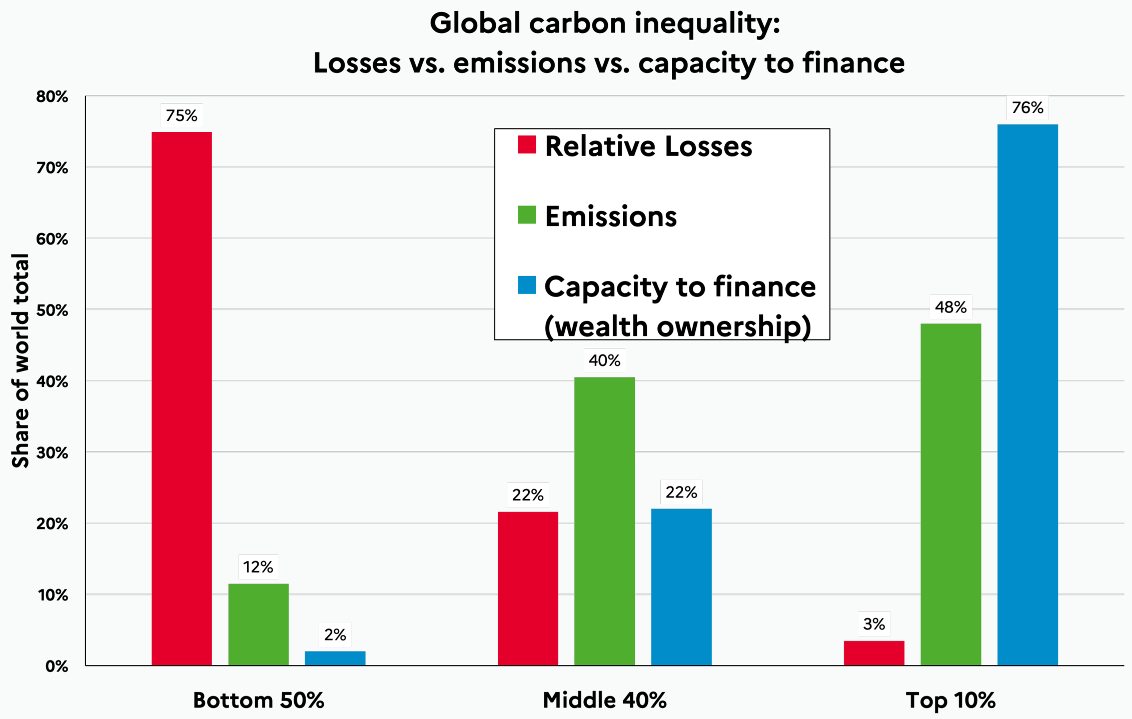

Figure A: Global climate inequality: relative losses, emissions and capacity to finance

Notes: Relative income losses due to climate change, vs. greenhouse gases emissions vs. wealth ownership. See Figure 29 for methodological details and how to read this graph.

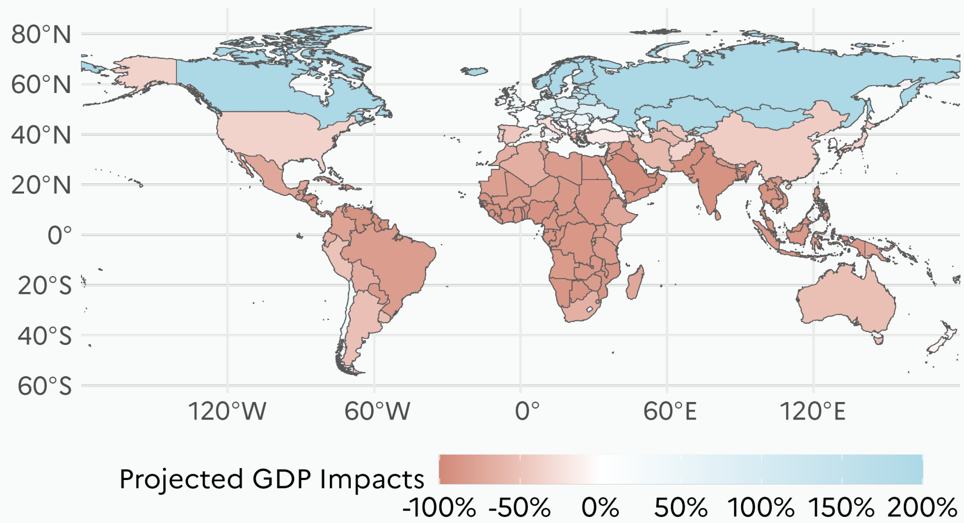

Figure B: Change in GDP per capita by 2100 attributable to climate change

Notes: See Figure 23. **Sources:** Burke, Hsiang, and Miguel (2015).

KEY FACTS

Inequality in Contributions

- The accelerating climate crisis is largely fuelled by the polluting activities of a fraction of the world population. The **global top 10% are responsible for almost half of global carbon emissions** and the global top 1% of emitters are responsible for more emissions than the entire bottom half of the world's population.

- Within-country inequality is a critical dimension of the global emissions distribution. It is found that **within-country carbon inequality now makes up the bulk of global emissions inequality, i.e. about two thirds of the total**, an almost complete reversal as compared to 1990.

- **The carbon budgets needed to eradicate poverty below the US$ 5.50/day poverty line are equal to roughly one third of the current emissions attributable to the top 10% of global emitters**. Reducing carbon consumption at the top can thus free up the required budgets to lift people out of poverty.

Inequality in Impacts

- Poverty and vulnerability to climate hazards are correlated and mutually enforce each other. Many **low-income regions are facing agricultural productivity losses of 30%** and more due to climate change which aggravates poverty and food insecurity.

- **Over 780 million people globally are currently exposed** to the combined risk of **poverty and serious flooding**, mostly in developing countries.

- Many countries in the Global South are significantly poorer today than they would have been in the absence of climate change. This trend is set to continue and result in **income losses of more than 80% for many tropical and subtropical countries by the end of the century.**

- Within countries, the poor suffer stronger losses from climate impacts than more affluent population groups. The **income losses from climate hazards of the bottom 40% are estimated to be 70% larger than the average** in low- and middle-income countries.

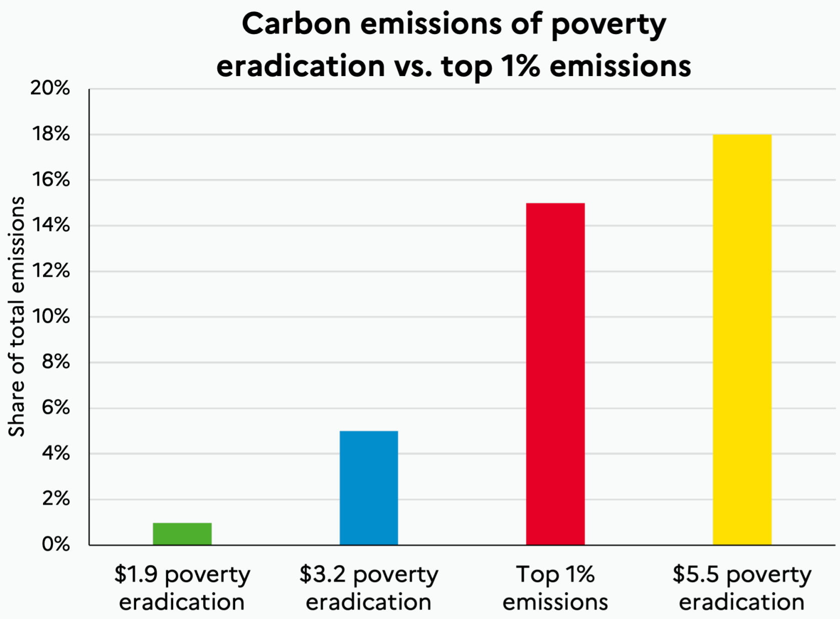

Figure C: Carbon budget of poverty alleviation and emissions from the global top 1%

Notes: Lifting one third of the world population over the $3.2/day poverty line would increase global emissions by 5% (blue bar). Global top 1% emissions are close to 15% (red bar) according to Bruckner et al. (2022). See Figure 9 for more information.

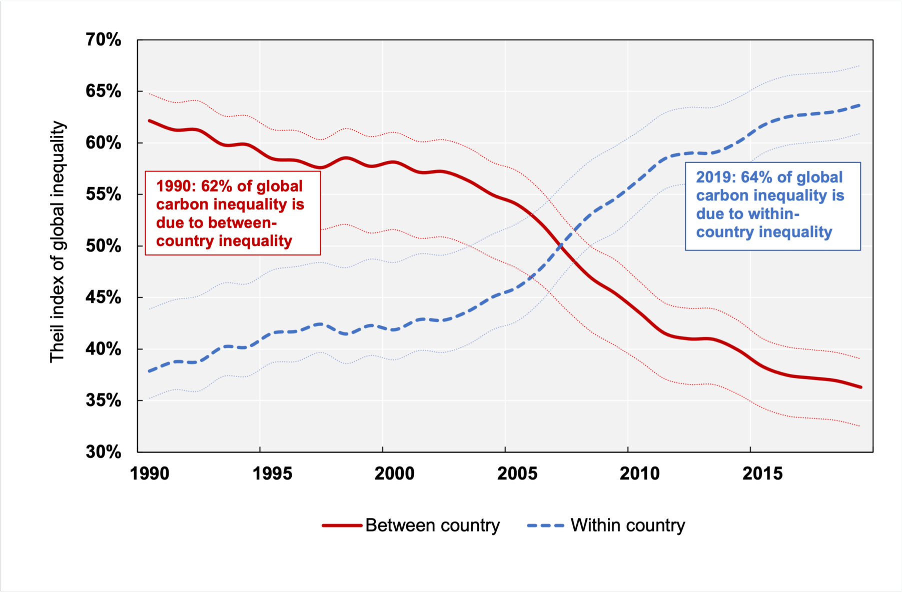

Figure D: Global inequality of individual emissions: between vs. within country inequality, 1990-2019

Notes: A relatively modest progressive wealth tax on global centimillionaires could fill the adaptation funding gap. See Figure Chancel, 2022 for more information.

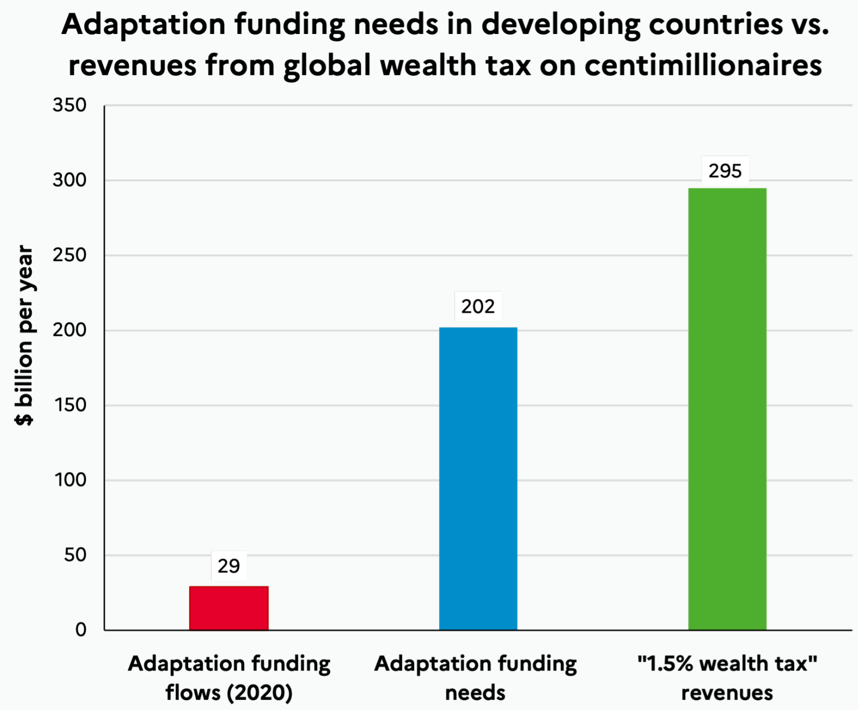

Figure E: Filling the adaptation funding gap in developing countries

Notes: A relatively modest progressive wealth tax on global centimillionaires could fill the adaptation funding gap. See Figure 38 for more information.

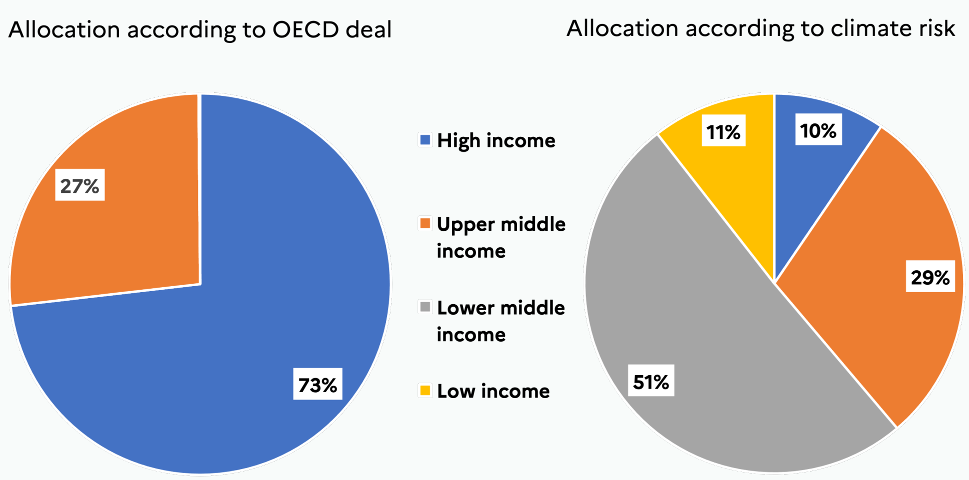

Figure F: New tax revenues from multinationals taxation: OECD proposal vs. climate risk

Notes: Projected revenues from the OECD "Pillar 1" proposal mainly go to high income countries. Alternative options can be envisaged to better integrate climate risk inequality. See Figure 35.

		What kind of climate policy?		
		Decarbonize energy-supply	**Increase decarbonized energy access**	**Switch in energy end-uses (building, transport, industry)**
Which social group is targetted?	**Bottom 50%**	Industrial policy: Public investment in renewables (on or off-grid); Social protection: increased transfers to workers affected by the transition	Public investments in low-carbon energy access (e.g. clean cookstoves, zero-carbon social housing)	Develop public transport systems: low-carbon BRT, rail, car-sharing strategies; energy retrofitting in social housing; cash-transfer to compensate increase in fossil energy prices
	Middle 40%	Same as above + Financial incentives to encourage middle-class investments in low-carbon energy. Bans on new fossil investments.	Subsidies for new housing construction; buildings energy regulation; penalty/bans on sales of inefficient housing	Same as above; stricker regulations and taxes on polluting purchases (SUVs, air tickets); subsidies on low-carbon alternatives (elec. vehicles).
	Top 10% & Top 1%	Wealth or corporate taxes with pollution top-up to finance the above & accelerate divestment from fossils; Bans on new fossils investments	Wealth or corporate taxes with pollution top-up (see left); fossil fuel subsidy removal	Strict regulation on polluting purchases (SUVs, air tickets); wealth or corporate taxes with pollution top-up (see left); carbon cards to track & cap high personal carbon footprints

Figure G: Inequality check for climate policies

Notes: See Figure 40. **Sources**: Authors, inspired by Rodrik and Stantcheva (2021).

Introduction

"The climate crisis is a case study in moral and economic injustice."

Secretary General A. Guterres
UN General Assembly, Sept. 2022

To date, calls for a sustainable, post-pandemic recovery seem largely to have gone unanswered. The years 2022-2021 saw economic activity bounce back sharply after the global recession induced by the Covid-19 pandemic in 2020. Global GDP quickly recovered, growing by almost 6% in 2021, thereby reaching pre-pandemic levels. Strikingly, global greenhouse gas emissions exhibited almost the exact same movement. In 2020, global emissions of CO2 and other greenhouse gases decreased by 5.2% only to attain an all-time high in 2021 in the largest annual surge in carbon emissions ever observed. The strong comovement of global GDP and carbon emissions (respective growth rates of 5.9% and 6% between 2020 and 2021) shows that economic output and greenhouse gas emissions remain far from being decoupled in global production processes (International Energy Agency, 2021). Almost simultaneously, the 6th IPCC assessment report warned that irreversible climate overshoot will be inevitable if global carbon emissions do not peak and then begin a persistent reduction between 2020 and 2025 (IPCC, 2022). Meanwhile, the year 2022 brought about another significant increase in carbon emissions.[1] With rising gas-to-coal switching, driven by the war in Ukraine, the required reversal in carbon emissions will remain a serious challenge in the near future. In the years since the signing of the Paris accord in 2015, global carbon emissions have grown by an average of 0.8% per year. In contrast, the rate of change necessary to stay below 1.5°C (with a probability of 67%) is estimated at -8% per year (Liu et al., 2022).

[1] Data at: https://carbonmonitor.org (Accessed 28.11.2022)

At the same time, the year 2022 brutally uncovered the reality of destabilizing climatic conditions. The mega-floods that hit Pakistan in August 2022 were preceded by a severe heat wave and drought which reduced the capacity of the soils to absorb the excess rainfall and melt-water from the countrys disappearing glaciers. Hence, the disastrous events that affected over 30 million people and ended in a death toll of more than 1,700 were caused by a combination of climate-related events (National Disaster Management Authority Pakistan, 2022; Waqas, 2022). That same month, Europe experienced one of its worst droughts in 500 years, drying up some of the continent's largest rivers and causing severe agricultural yield losses.

There is no doubt that the climate crisis has begun to materialize. Even if we can limit global warming to 1.5°C, there will be sustained consequences for eco-systems and socio-economic systems. These include reduced food and water security in many regions of the world due to more frequent and intense extreme weather events. Reduced agricultural output contributes to increased food price volatility, thereby putting low-income households at serious risk of food insecurity. Effects on agriculture have been most severe in mid- and low-latitude regions so far, and are projected to significantly aggravate malnutrition in many areas of the global south (Bezner Kerr et al., 2022). Approximately half of the worlds population is currently exposed to acute water scarcity for at least some moments in the year. More than one quarter of the world's population currently does not have access to safe drinking water at home (World Health Organization and UNICEF, 2021).

Climate change contributes to economic and material deprivations in myriad ways, now very well documented. It aggravates water scarcity and creates water insecurity (Caretta et al., 2022). Extreme heat has had significant effects on mortality, causing tens of thousands of additional deaths every year. These deaths occur mostly in tropical and subtropical regions. Threats from extreme heat are particularly menacing in urban areas and pose serious threats to infrastructure in those areas (e.g. sanitation and energy systems).

These risks are predicted to rise rapidly in the medium term as an increasing share of the global population concentrates in vulnerable urban centres (Dodman et al., 2022). Risks to both physical and mental health are very likely to increase as climate change unfolds. Mental health challenges, such as climate-related anxiety, have been shown to be particularly strong among children/adolescents and people with underlying health conditions. Infectious diseases such as dengue fever and malaria will spread more rapidly as climatic conditions for their transmission improve (Cissé et al., 2022). Tropical cyclones, floods, and droughts have forcibly displaced millions of people, mostly in low-income countries. Such climate-induced migration is predicted to increase significantly and expand within certain regions in the coming years (Cissé et al., 2022). Several eco-systems have been damaged irreversibly with potentially devastating consequences for communities that directly depend on them for their livelihoods. Continually rising sea levels will render large swaths of coastal land inhabitable and pose serious dangers for the provision of safe drinking water in many areas of the world. The value of global assets in areas subject to significant flood risk (1-in-100-year flood) is estimated to increase to US$ 12.7 trillion in 2100 under RCP4.5 (upper bound estimate), which is equivalent to approximately 15% of global GDP in 2020 (Glavovic et al., 2022). The broad range of already visible climate change impacts demonstrates that, when it comes to mitigation, every fraction of a degree matters. It follows that every tonne of carbon matters.

Humanity as a whole is facing the climate crisis and humanity as a whole must act against it. It is clear, however, that humans neither contribute nor are affected in the same way by climate change. As the latest IPCC report has shown, summarizing decades of research on the question, the inequality is apparent at the country level, with the Global South disproportionately affected by temperature change and its impact on soils, by extreme weather events, and by the spread of disease. This pattern also holds within each country, in the Global South and the Global North: individuals contribute differently to carbon emissions, and are not equally equipped to tackle its effects. The link between heat-wave deaths and socio-economic conditions is strong, as is the link between individual incomes and overall contributions to emissions. While the connection between inequality and climate change contributions and impacts has been well researched (Chancel, 2022; Hallegatte, Bangalore, et al., 2016; IPCC, 2022) policies to tackle climate change do not always place distributional concerns at their core. Yet beyond the inherent ethical considerations, a failure to do so could be particularly deleterious for the political and economic effectiveness of climate policies. It is therefore necessary to better understand climate change inequalities (and in particular those occurring within countries) and what they imply for public policies. The aim of this report is to do just that, by reviewing the latest research on the distributional consequences of climate change and climate change policies, and discussing options for the better integration of social justice into the very design of climate policies - a dimension still largely missing from current policy thinking. This report is based on a synthesis of the latest research into these questions, complemented by novel empirical work and a set of interviews with climate and development policy experts across the world.

The rest of this report is organized as follows: **Section 1** presents the latest research findings on inequality in greenhouse gas emissions between and within countries. **Section 2** reviews recent research on the inequality of impacts, while **Section 3** discusses options to integrate inequality into the heart of climate policy design.

# 1. Unequal contributions to climate change

1.1. Why do inequalities in emissions matter?

Environmental policy needs to incorporate inequality considerations. Many well-known environmental policy instruments are based on the observation that greenhouse gases are global pollutants and hence, where and by whom they are emitted does not matter for climate change mitigation per se. This is the rationale behind emission trading schemes, for instance, considered by many economists to be the most efficient mechanism for emission reductions. Such policy instruments do not require information about the distribution of emissions across a population (i.e. who emits what)[2], but supposedly ensure that reductions occur where they can be realized at the lowest cost. Similarly, one might argue that global emissions must reach net zero by 2050. Thus, if all carbon emissions must be cut regardless of where they originate from, what is to be gained from additional information about their current distribution across population groups?

All individuals contribute to emissions, but not in the same way. While carbon emissions will eventually have to be cut completely, the pathway to get there will matter for political, economic or efficiency reasons. Who must bring down their emissions, at what pace and when? Knowing the current emission levels of different social groups is paramount to providing an equitable answer to such questions. It seems likely that the same absolute reduction in emissions is relatively easier to achieve for high-income individuals (or firms) than for low-income and low-emitting groups whose carbon emissions are linked to essential needs such as domestic heating or commuting and who have little economic resources to afford change. Thus, in addition to an obvious equity concern, there appears to be an efficiency question at stake. The "marginal effort" required to achieve the same level of emission reduction might be significantly lower for high-emitting groups, which creates an incentive for policies that target this group. Furthermore, it may be that strong inequalities in emission levels impede effective mitigation. For instance, the consumption patterns of the top emitters who own larger dwellings, drive larger cars, consume more goods, frequently undertake long-distance travel, may create what sociologists have termed Veblen effects:

[2] Aside from information about the emissions of regulated facilities

by associating their consumption levels with social status, the top emitters may induce higher levels of carbon intensive consumption among the middle classes than in a more equal scenario[3]. Finally, responsibility for emissions is not only about the consumption of goods and services that produce carbon, but also about individual investments in more or less carbon-intensive activities. Here again, inequality matters a lot as it is well established that investment decisions, and private capital ownership, are very unequally distributed in our contemporary economic systems: in most countries (both rich and poor), one half of the population owns around just 5% of everything there is to own (Chancel, Piketty, et al., 2022).

Better understanding how groups may win and lose from the energy transition is key to accelerating it.[4] It is also necessary to draw policy conclusions from the fact that the top emitters are likely to be relatively well protected from the adverse consequences of climate change. The incentives to reduce their emissions do not necessarily match the damage those emissions cause. Again, this can be true between countries as well as within them. Quantifying inequalities in carbon emissions allows us to be more explicit about these issues and can help to facilitate effective mitigation policies as well as public debate around these important questions. The point is not to delay action by blaming some groups (i.e. the rich) and absolving others (i.e. the poor) from acting: the objective is rather to better understand the potentially conflictual nature of the energy transition, the various possible coalitions of winners and losers associated with certain climate policies (or to the pursuit of business as usual) in order to accelerate change.Political history indeed reveals that major social changes rarely occur without a certain degree of conflictuality within a given society. The key question is how to organise disagreements between social groups in a peaceful, democratic manner. Monitoring inequalities in emissions and in mitigation efforts between groups of emitters can help to go in this direction.

1.2. Within-country carbon inequality explains the bulk of global carbon emissions inequality

There are vast historical inequalities in emissions between regions. The 2015 Paris Agreement acknowledges that the historical contributions to anthropogenic global warming are extremely hetero-

[3] See Veblen (1898) and Chancel, 2020 for a broader discussion of these issues.

[4] On these issues, see the work carried out by the UNDP over the past years and upon which this report also draws (UNDP, 2020, 2022a,b,c).

geneous across countries and world regions. Virtually all low-income countries have emitted negligible shares of carbon throughout the past century compared with the rich countries. For instance, North America and Europe created half of all accumulated global GHG emissions since 1850. Thus these two continents have contributed as much to anthropogenic climate change as all the other countries put together, despite having but a small fraction of the global population (see Figure 1). This pattern of unequal carbon emissions across regions and countries extends into the present.

Current inter-regional inequalities in average emissions remain large.

Today, the carbon footprint of the average US American is almost ten times as great as that of the average Indian. This ratio is even more extreme for many countries in Southern and Eastern Africa, which typically have the lowest per capita carbon emissions in the world. If emissions were equally distributed across countries today, the average citizen of the Democratic Republic of Congo, for example, would see their emission levels increase ten-fold while Europeans and North Americans would experience a drop in their emissions levels of almost 40% and over 70% respectively. Hence, despite rapidly increasing emissions in some emerging countries such as China, both the historical and current distribution of carbon emissions across world regions are strikingly unequal. This pattern of inequality implies differentiated responsibilities for climate change mitigation. Thus, while the remaining carbon budget that can be emitted before reaching 1.5°C of global warming is small compared with the historical volume of emissions, an equitable mitigation path should take these unequal contributions into account.

The argument of differentiated responsibilities becomes even more compelling when comparing current emission levels with the hypothetical per capita budgets that would be in accordance with the targets agreed upon in the Paris accord. These levels are obtained by equally dividing the CO2e left to be emitted until 2050 in order to stay below the 1.5°C threshold among the projected world population. This budget (global equally split carbon budget) amounts to 1.9 tCO2e per capita each year until 2050 if the climate targets are to be reached with a probability of 83% (IPCC, 2021).

Figure 2 compares these budgets with 2019 emission levels by region. The current global per capita average exceeds the budget compatible with the 1.5°C target by about four tonnes of CO2e per year (Chancel, 2022). In some regions, however, current per capita emissions are in line with the Paris targets,

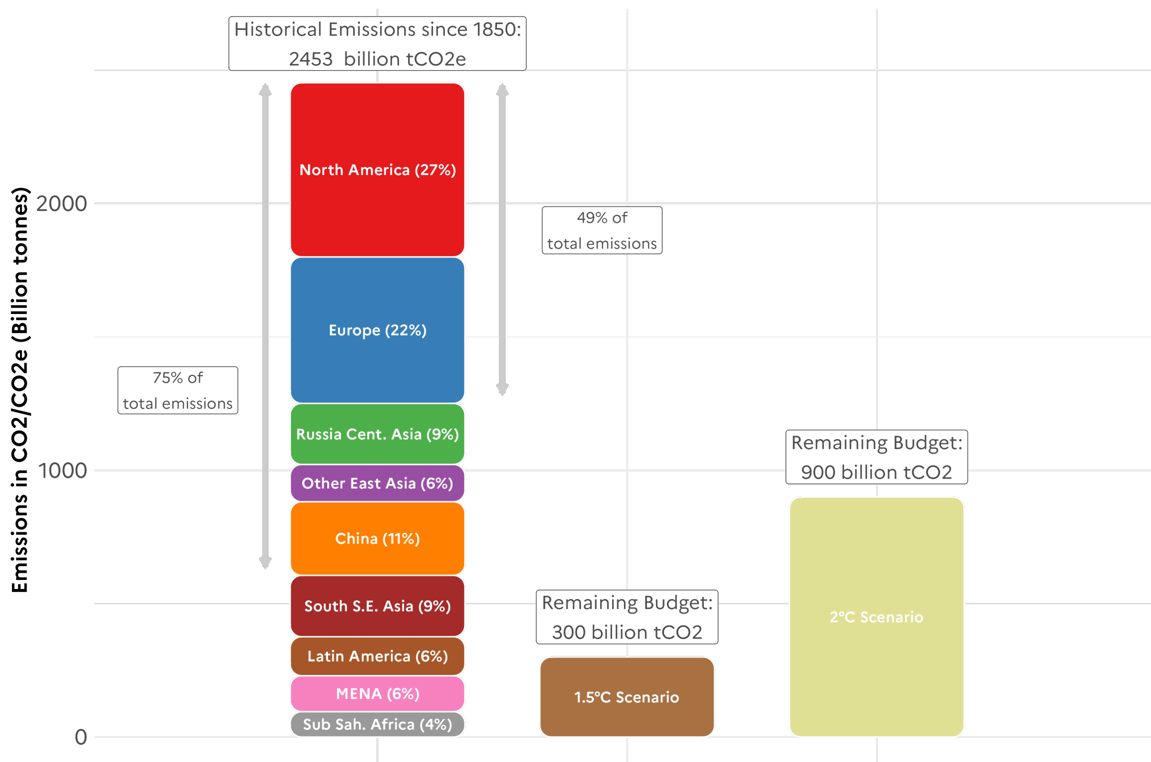

Figure 1: Accumulated historical CO2 emissions vs remaining carbon budgets in 2020

Notes: The remaining carbon budgets to meet the Paris targets are small compared with the amount of greenhouse gases already emitted. Together, North America and Europe account for half of all historical emissions. **Sources:** Chancel (2022)

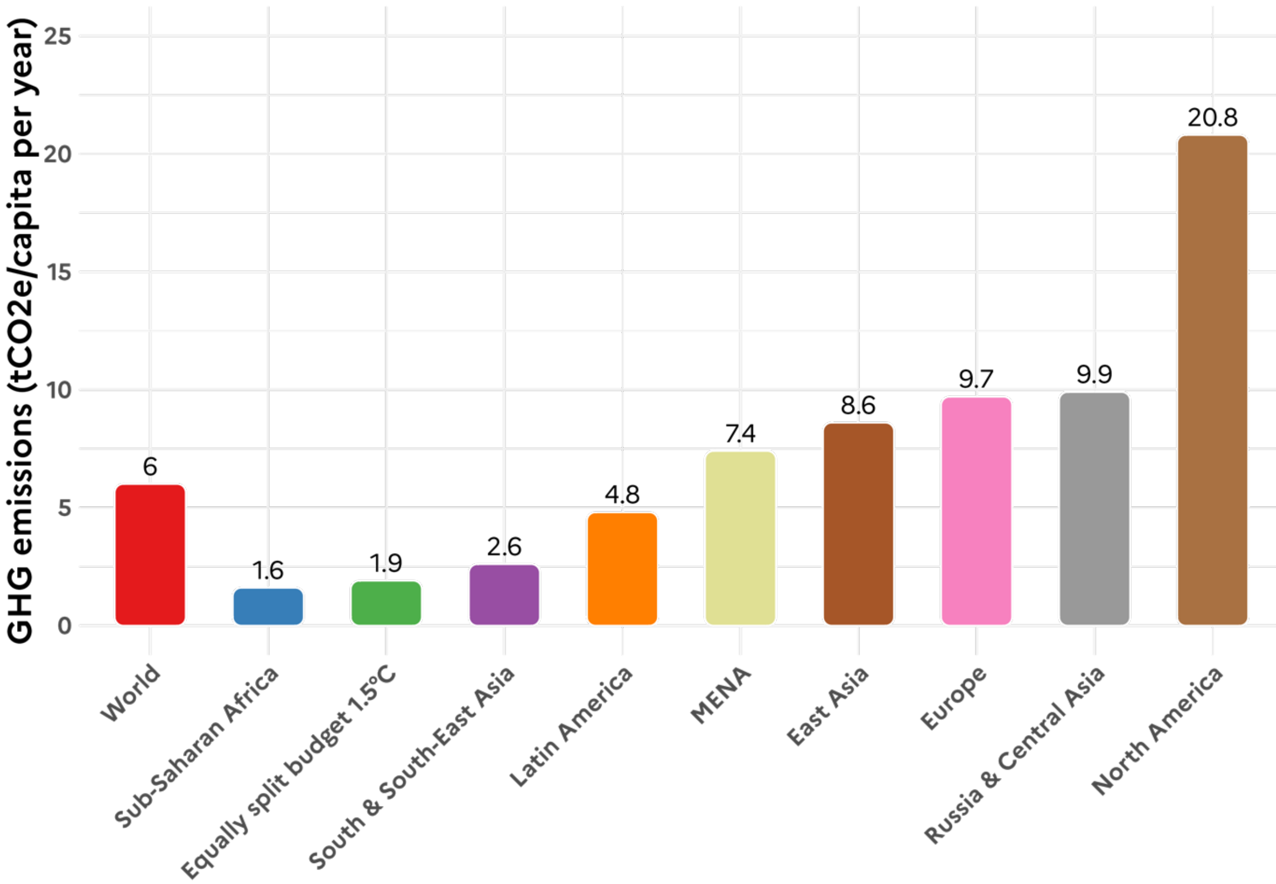

Figure 2: tCO2e/cap per year by region vs remaining budgets for 1.5°C, 2019

Notes: Emission levels in most high- and middle-income regions exceed equally split budgets by several orders of magnitude. On the contrary, average emissions in some regions of the Global South are in line or very close to the budgets compatible with a just 1.5°C scenario. Values include emissions embedded in international trade but exclude land use, land use change, and forestry. Source: **Sources:** Chancel, 2022.

and Sub-Saharan Africa is the only region where average per capita emissions currently meet the 1.5°C target. Indeed, annual per capita emissions in Sub-Saharan Africa could increase by almost 20% and still be in line with the 1.5°C target. All other regions overshoot the target considerably. South and South-East Asia and Latin America, with per capita emissions of 2.6 and 4.8t CO2e respectively in 2019 exceed the budget but remain within reach of the Paris targets. North America is a noticeable outlier with emission levels exceeding the 1.5°C budget by a factor of more than ten. Combining the evidence on historical and current emissions, it seems safe to say that the current climate crisis is largely attributable to excessive emissions in some parts of the world while the contributions of others are negligible.

There are significant inequalities between individuals both within regions and at the global level. Sizeable differences in the average per capita levels of carbon emissions can be observed across countries and regions. At the same time, comparing country-level averages can mask the underlying contributions of different population groups. Recent research has put a particular focus on the distribution of greenhouse gas emissions among different emitter groups across but also within countries. Per capita emissions of greenhouse gases for the bottom 50%, the middle 40%, the top 10% and the top 1% of global carbon emitters are shown in Figure 3. These numbers are constructed by linking data on the carbon emissions of different sectors obtained from environmentally extended input-output analysis with information about the income and wealth distribution (see Technical Box for more details). The carbon emissions are then distributed across the population based on national data and modeling on the link between carbon emissions, income and wealth, respectively, obtained from micro-level data.

Let us stress at the onset that these numbers remain highly perfectible, given the relatively limited data available at the country level to properly track inequality in emissions. Let us also note that there are various methodological ways to measure carbon footprints and none is perfect. Nevertheless, the methodology mobilized here is useful as it allows for the attribution from nearly all emissions in the world, while avoiding double-counting and differentiating between emissions from individual consumption and those that can be associated with individual investments. While much remains to be learned about the measurement of emissions inequality, these numbers already provide useful orders of magnitude to help frame debates on the energy transition.

At the global level, it appears that emissions are strongly concentrated within a relatively small group of the global population. The top 10% of emitters are responsible for almost half of all global carbon emissions, as has also been shown by previous studies (Bruckner et al., 2022; Chancel and Piketty, 2015; Kartha et al., 2020). In other words, the emissions caused by the bottom 90% of the global population are only marginally larger than those generated by the top 10%. According to Chancel (2022), the top 1% group creates more than one sixth of global emissions with per capita emission levels more than 16 times above the global average in 2019. These numbers imply that total carbon emissions by the top 1% largely exceed emissions by the entire bottom half of the global population - or to put it more drastically, the consumption and investment choices of a fraction of the population are causing significantly more ecological harm than the entire bottom half of the world's population combined.

Bruckner et al. (2022) also analyze the contributions of different groups to global emissions based on data from expenditure surveys, and propose an alternative methodological approach which gives slightly different results in absolute terms, at the global level, as compared to Chancel (2022). The overall pattern i.e. a strong concentration of emissions at the top of the distribution and negligible contributions to overall emissions of the bottom half of the global population is confirmed by both studies as well as other recent work.[5]

The strong concentration of global carbon emissions within a relatively small population group reflects two important dimensions of carbon inequality. On the one hand, it is driven by the large differences in emission levels across countries and the fact that most of the top emitters live in the countries with the highest aggregate carbon emissions. The second dimension is linked to the distribution of CO2e emissions within countries and regions. Figure 4 shows the carbon footprints of the bottom 50%, the middle 40% and the top 10% across regions of the world. The general pattern is unambiguous in all regions - there are large inequalities in emissions within regions as well as at the global level.

In East Asia, the top 10% emit 40t CO2e per year and per person, a larger footprint than that of the top 10% in Europe. In contrast, average emissions of the bottom half of the East Asian population (2.9t/year) are much lower than those of the European or North American bottom 50%. Average emission levels of the bottom half of the population in North America are comparable to those of the European middle 40% and the top 10% in South and South-East Asia, and

[5] The analog of Figure 3 based on the data in Bruckner et al., 2022 is reported in the Appendix for comparison.

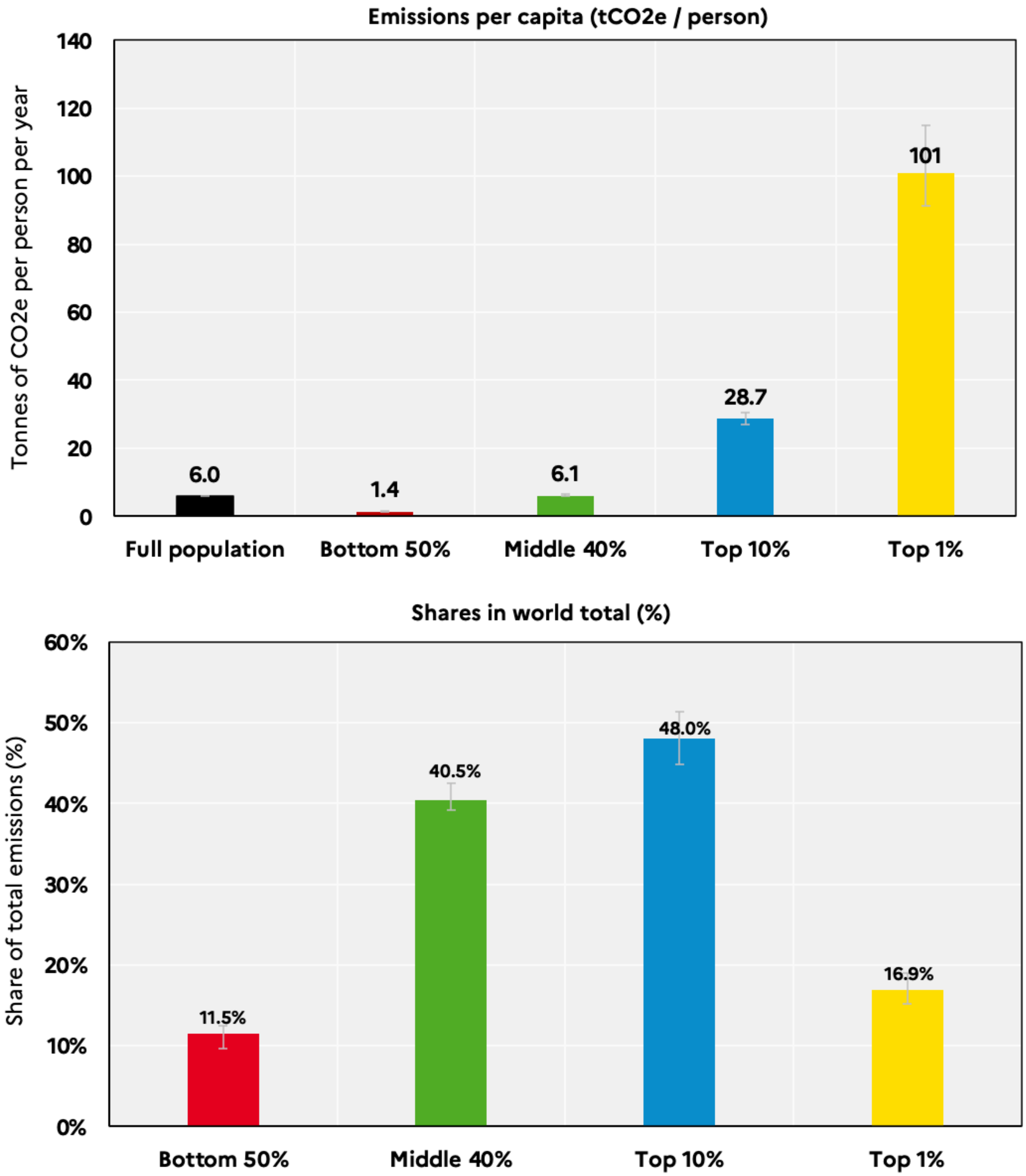

Figure 3: Emissions by global emitter group and shares in world total, 2019

Notes: The distribution of carbon emissions across the global population is very unequal. The current acceleration of anthropogenic climate change is largely driven by emission levels at the top of the distribution. Modelled estimates based on the systematic combination of household surveys, tax data, and environmental input-output tables. Emissions include footprints associated with consumption and investments. Values also take into account the carbon embedded in international trade. **Sources:** Chancel (2022) even considerably exceed the footprint of the top 10% of the population in Sub-Saharan Africa. The carbon footprint of the top 10% in North America is by far the largest in the world, exceeding that of the next largest top 10% footprint (East Asia) by more than 70%. The distribution of emissions in the MENA region and Russia and Central Asia is roughly comparable to that in Europe, albeit with larger footprints for the top 10%. In fact, the ratio of the emissions of the bottom half to the top 10% of the population is highest in the MENA region, where the top 10% emit over 15 times more CO2e than the bottom 50%. This is closely followed by Sub-Saharan Africa with a similar ratio. The carbon footprint of the bottom half of the population in SSA is the smallest in the world by a wide margin, while that of the top 10% is in the same range as the middle 40% in the MENA region and East Asia. It is also noteworthy that the top 10% of the population in Sub-Saharan Africa emit less CO2e than the bottom half of the North American population.

Current emissions of low-income groups often near per capita targets set by rich countries for 2030

The emissions of the bottom half of the population are close to or in line with the 1.5°C target in all regions but North America and Europe. In certain countries and regions, emissions of the middle 40% are also in line or close to the 1.5°C equally split target (e.g. South and South-East Asia and Sub-Saharan Africa). By contrast, nowhere in the world do the emissions of the top 10% meet the Paris targets, although there are marked differences across regions. This clearly illustrates the importance of emission inequalities within countries and regions for the overall picture of carbon inequality. Chancel (2022) estimates that while in 1990 a little less than two thirds of global carbon inequality was due to between-country inequalities, in 2019 global carbon inequality is mostly driven by differences in the emission levels of different population groups within countries (accounting for close to two thirds of the difference).

1.3. Contrasted carbon inequality profiles in low and middle income countries.

Figure A.3 in the Appendix illustrates this national dimension of carbon inequality by showing per capita carbon emissions estimates by income group for a sample of four low- and middle-income countries. In the Democratic Republic of Congo, the poorest of the four displayed countries, the poorer half of the population emits roughly 0.25t CO2e per year. This pattern is repeated in many low-income countries in Central and Eastern Africa, where the carbon footprint of the poorest half of the population is barely noticeable

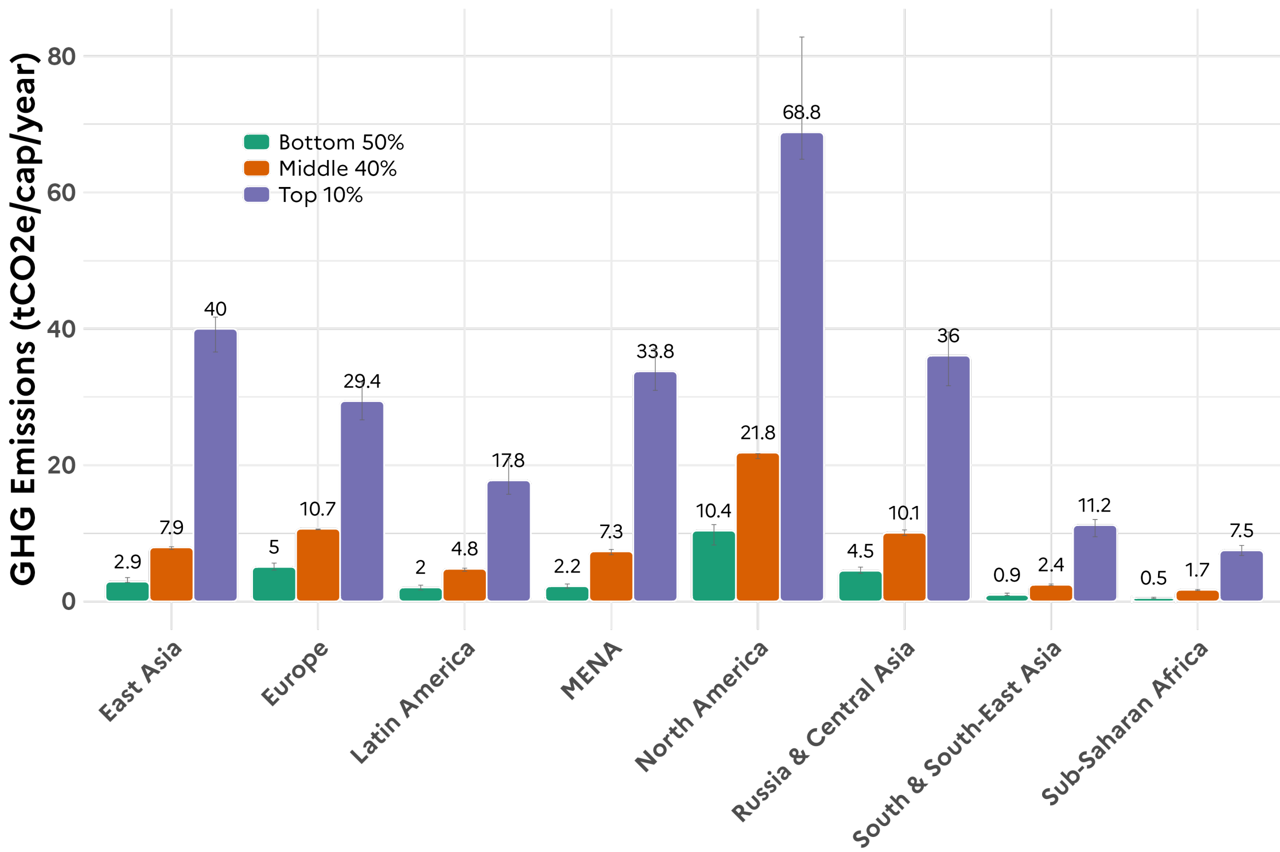

Figure 4: Carbon footprints by group across the world 2019

Notes: This graph shows that carbon inequality is not just an issue of high- vs. low-emitting countries. Intra-regional inequalities in carbon emissions are also very pronounced. Modelled estimates based on the systematic combination of household surveys, tax data, and environmental input-output tables. Emissions include footprints associated with consumption and investments. Values also take into account the carbon embedded in international trade. **Sources:** Chancel (2022).

against the global picture. While relative inequalities are nonnegligible in these countries, even the per capita emissions of the top 10% groups are typically close to the carbon budgets that would accrue to them in an evenly distributed 1.5°C scenario.

The conclusion is slightly different for the remaining three countries shown in Figure A.3. The carbon footprints of the bottom 90% in Nigeria and India are strikingly similar, and compatible with the 1.5°C goal in both countries. There are significant differences, however, among the top emitters. While the per capita emissions of the top 10% Nigerians exceed those of the bottom half by a factor of roughly five, this ratio is more than twice as great in India where the top 10% emit almost 10t CO2e per year, and is thus range in a region comparable to the European middle class or groups above. The main effect at play here is the higher level of income and wealth inequalities in India as compared to Nigeria. The higher emission levels in all population groups in Colombia are reflective of the higher relative income levels compared to the other countries. The top Colombian emitters are found to be responsible for roughly 14t CO2e per capita and year, which is approximately 1.5 times the size of the biggest Indian footprints. It appears, then, that although the carbon footprints in most low-income countries are relatively low, countries such as India and Colombia do exhibit a significant degree of carbon inequality, driven by a high concentration of income, wealth, and carbon intensive activities in a relatively small population group. On the other side of the coin, the average carbon footprint of the majority of the population in these countries remains below the footprint they would be allocated in an equally distributed 1.5°C scenario. In very poor countries such as the Democratic Republic of Congo this often applies to almost the entire population.

Distribution of emissions in emerging and high-income countries. Figure A.4 shows the same distribution of per capita emissions across income groups for China and the US. Average emissions in both countries are significantly above the thresholds that would be in line with the 1.5°C goal. In order to meet the Paris targets for 2030, both countries would have to substantially reduce their aggregate emissions. Nonetheless, there are large differences in the degree of overshoot, particularly when factoring in responsibilities associated with individuals' savings and investments. The top 10% of emitters in China are directly or indirectly responsible for almost 38t CO2e per capita, which largely exceeds the emissions of the top emitters in many high-income countries. At the same time, the bottom 50% of the Chinese population have a carbon footprint of less than 3t CO2e. This means that the poorer half of the Chinese population only generates 17% of total carbon emissions in China while the top emitters are responsible for almost half of them. This share is comparable to that of the top 10% emitters globally and thus represents an enormous level of carbon inequality within China.

While average emissions in the US already exceed the footprints of the top emitters in many developing countries with nearly 21t CO2e per capita, the richest 10% of US Americans are found to be responsible for about 70t CO2e per capita. They would thus have to cut their emissions by more than 80% in order to reach levels implied by US official 2030 pledges, when these pledges are expressed in per-capita terms (about 10t CO2e per person per year by 2030). The bottom half of the US population is found to be near the 2030 pledged target for 2030. To be clear: no group in the US is in line with equally split global carbon budgets and all groups will need to see their emissions brought down to zero, but all groups do not have the same mitigation efforts to make to get there.

Unequal dynamics of global carbon inequality since 1990. As discussed in the introduction to this report, global greenhouse gas emissions continue to rise despite the urgent need for drastic emission cuts. Figure 5 plots the growth rate of per capita emissions between 1990 and 2019 by percentile rank in the global emitter distribution. The bottom 75% of global emitters have seen a relatively uniform growth in their per capita emissions over the past 30 years, which can be attributed mainly to rising incomes and consumption in developing and emerging countries. However, because this group started with comparatively low emission levels, their growth represents only a moderate contribution to overall emissions growth. Precisely, the increase in per-capita emissions of the bottom 50% of global emitters accounts for 16% of emissions growth between 1990 and 2019 at the global level. Strikingly, those between the 75^{th} and the 95^{th} percentile of the emissions distribution have seen their per capita emission levels drop over the past 30 years by rates of up to 15%. This group overlaps largely with the low-income and middle classes in rich countries, who have seen their income shares stagnate or even decrease in the past 30 years (Alvaredo et al., 2018). This contrasts strongly with the groups at the top of the pollution distribution whose per capita emissions increased rapidly. This is particularly true for the top 1% of global emitters, who are responsible for 23% of the total growth in emissions between 1990 and 2019. Hence, the top 1% of global emitters have contributed more to the growth of carbon emissions in recent decades than the entire bottom half of the world

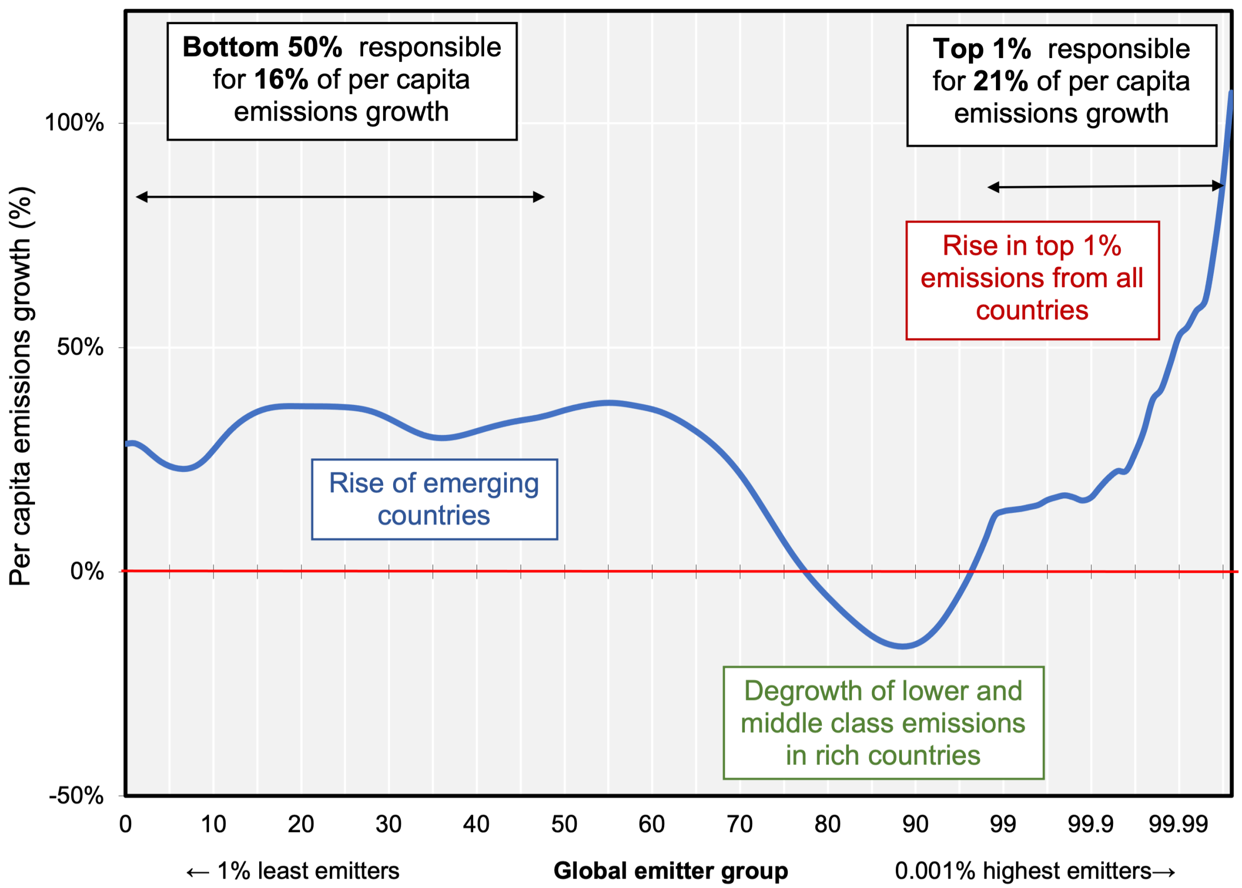

Figure 5: Per capita emissions growth by percentile of global emissions distribution, 1990-2019

Notes: The top 1% of global emitters are found to be responsible for almost one fourth of the growth in greenhouse gas emissions since 1990. This contribution to emissions growth during the observed period significantly exceeds that of the entire bottom half of the global population. Lower and middle classes in high-income countries reduced their per capita footprints. Modelled estimates based on the systematic combination of household surveys, tax data, and environmental input-output tables. Emissions include footprints associated with consumption and investments. Values also take into account the carbon embedded in international trade. **Sources:** Chancel (2022).

population. The most high-polluting individuals have almost doubled their carbon footprints since 1990.

Between 1990 and 2019, it is also found that the role of within country carbon emissions inequality rose significantly. In 1990, about 62% of the global inequality in individual carbon emissions was due to average emissions differences between countries. In 2019, the situation has been reversed: 64% of the global inequality in emissions is now due to differences within countries, as presented on Figure 6.

1.4. Consumption and investment patterns drive unequal contributions to climate change

Inequalities in carbon footprints stem from inequalities in the consumption and investment patterns of different income groups

What drives the large inequalities in carbon emissions discussed in the previous section? Let us first stress that all studies on this question show that there can be large variations in direct energy consumption (energy associated to car use, or to heating purposes) within a given income group in a country (see Pottier (2022)). Whether individuals live in urban or rural areas, whether they live alone or in a family, whether they use fuel or firewood for heating, or live in insulated homes or energy-inefficient dwellings, matters a lot in determining their carbon footprints. That said however, despite potentially large variations within each income group, emissions associated with direct energy consumption tend to increase with income levels in most countries.

This correlation becomes even more apparent when we factor in emissions associated with individual consumption of goods and services. These are emissions associated with the production, distribution and sale of goods that people buy, and are also known as "embedded emissions". When we take these into account, the link between income and emissions becomes even stronger (although variations still occur within income groups). A further dimension one may want to look at is emissions associated with individual savings or investments. It is not easy to take these two categories into account and doing so raises important methodological questions which are not yet fully solved, but going in this direction is useful. If individuals are attributed some responsibility for their consumption choices, then it is reasonable also to take account of choices such as investing in a given company and owning shares in that company.

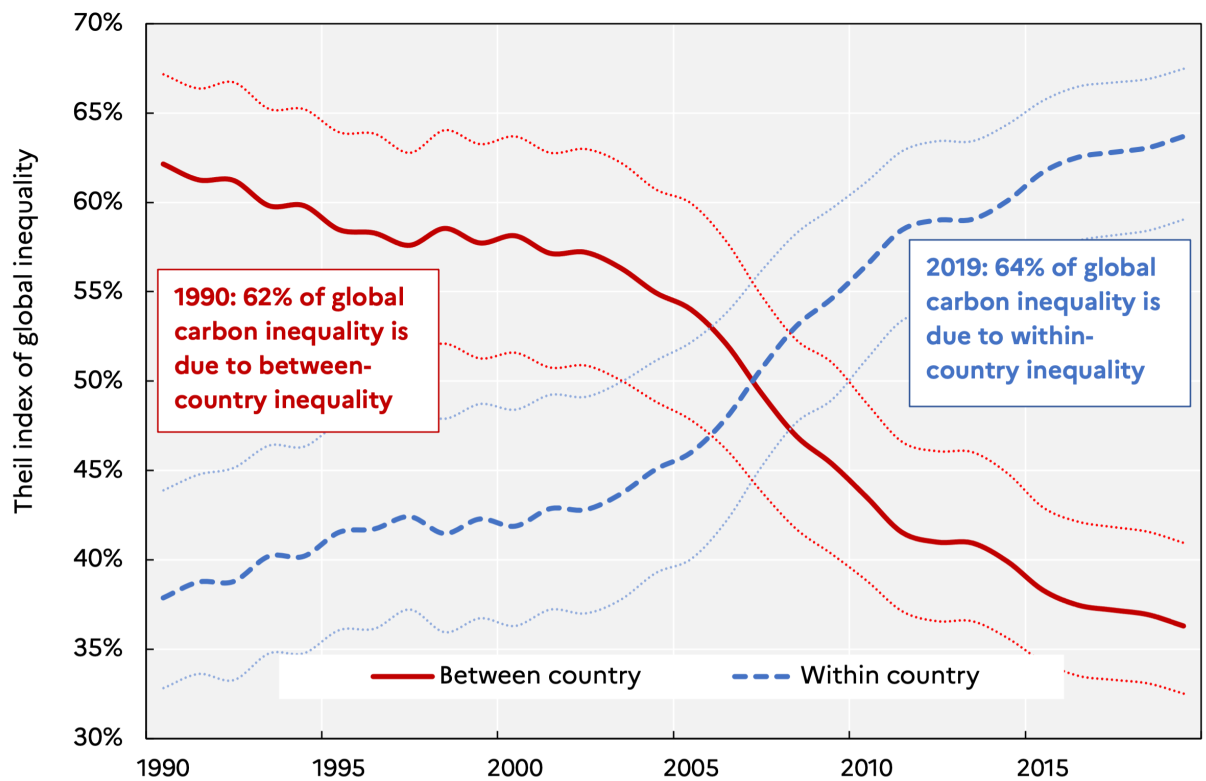

Figure 6: Global inequality of carbon emissions: between- vs. within-country, 1990-2019

Notes: In 1990, about 62% of the global inequality in individual carbon emissions was due to average emissions differences between countries. In 2019, the situation has reversed: 64% of the global inequality in emissions is now due to differences within countries. Results show a decomposition of global inequality as per the Theil index. Modelled estimates based on the systematic combination of household surveys, tax data, and environmental input-output tables. Emissions include footprints associated with consumption and investments. Values also take into account the carbon embedded in international trade. **Sources:** Chancel (2022).

Technical Box: Income, elasticity, and emissions

It is important here to distinguish between the carbon *intensity* of a given consumption good and an overall level of consumption of that good. A recent survey of the literature on the link between income, expenditure, and emissions associated with consumption finds that when income and expenditure increase, emissions associated with consumption also increase, in all countries (Pottier, 2022). More precisely, increasing household income (or expenditure) by 1% will lead to a positive, though smaller, relative increase in greenhouse gas emissions embodied in household consumption. This implies that while a marginal unit of expenditure is less carbon intensive for the rich than for the poor, emissions still strictly increase with overall expenditure (or income), but at a slower rate. It is also worth noting that expenditure elasticities of carbon emissions tend to be higher than income elasticities. This is simply due to the fact that richer households spend a smaller share of their income on consumption. Hence, a smaller fraction of a marginal unit of income given to high-income household goes into consumption goods whose embodied emissions can be accounted for. This effect is cleared away when considering the expenditure elasticity, as this measure only accounts for money actually spent on consumption. Hence, the volume effect is relatively straightforward. As income increases, households spend more money on consumption in absolute terms and thus are responsible for more carbon emissions, either through direct energy consumption (e.g. the burning of petrol when driving) or through indirect emissions embedded in consumer goods. Given these results and the strong concentration of income, it is not surprising that strong carbon inequalities persist.

It is crucial not to misunderstand the implications of an income elasticity with respect to emissions less than unity. It certainly does not imply that consumption becomes "clean" when income or consumption increases. In fact, some of the most energy-intensive goods are consumed almost exclusively by the rich according to available household consumption surveys (Oswald, Owen, and Steinberger, 2020). Examples of such goods are vehicle fuels and package holidays, the consumption of which are almost entirely attributable to high-income individuals. At the same time, there are other luxury goods with relatively low energy intensity including communication and recreational items such as musical instruments.

Since the energy requirements and hence carbon footprints of these latter goods are relatively small, their increasing share in the consumption basket of high-income households attenuates the effect of the more polluting luxury goods, at least to some extent.[a] Figure 8 provides a classification of different types of consumption goods by their energy intensity and the income elasticity of demand. It is important here not to confuse the different elasticities and to maintain a firm grasp on the implications of the results. The income elasticity of demand measures how sensitive demand for a certain good is to income changes of the consumers. A value larger than one implies that the relative change in demand is stronger than the relative income change. These goods are represented in the two upper quadrants of Figure 5 and referred to as luxury goods by Oswald, Owen, and Steinberger, 2020, as they are only consumed in sizeable quantities at comparatively high income levels. The opposite is true for the goods in the two lower quadrants of the graph. Their consumption is relatively inelastic to income, meaning that the consumption of these goods changes relatively little when income changes. This is typically the case for basic goods such as food and heating that need to be consumed almost regardless of current income.

Figure 8 further distinguishes the consumption categories by the energy intensity of their consumption (below or above median intensity). This includes emissions generated by their direct use, such as the burning of fuel (Scope 1), emissions from energy combustion used in their production (Scope 2), and indirect emissions generated along the supply chain (Scope 3). The key insight from Figure 8 is that almost all consumption categories with high energy intensity are located in the upper right quadrant of the graph, i.e. their consumption is associated with higher incomes, with the notable exception of heat and electricity. At the same time, a significant fraction of luxury goods are relatively less energy intensive (upper left quadrant of Figure 7). Because the consumption of these goods also rises with income, a marginal increase in income and thus overall consumption results in a smaller increase in energy consumption than a marginal income increase at the bottom of the distribution. However, it is important to bear in mind that the consumption of all goods is strictly increasing in income (albeit at varying rates). This brings us back to a simple argument made above: being richer results in higher aggregate consumption levels and therefore induces a volume effect that brings about large inequalities in energy footprints. Oswald, Owen, and Steinberger, 2020 estimate that the global top 10% of energy consumers account for 39% of global energy consumption in 2011 which is just marginally less than the entire bottom 80%. While the relation between energy consumption and carbon emissions depends on the carbon intensity of energy production, they are nonetheless strongly linked across the globe (R. Jackson et al., 2018). Hence, consumption profiles may partially explain the concentration of emissions among relatively small (typically high-income) population brackets.

[a] Note that Oswald, Owen, and Steinberger, 2020 focus on the energy intensity of different consumption categories rather than the carbon footprint. However, when the composition of energy sources does not vary substantially across income groups, the two measures are almost proportional.

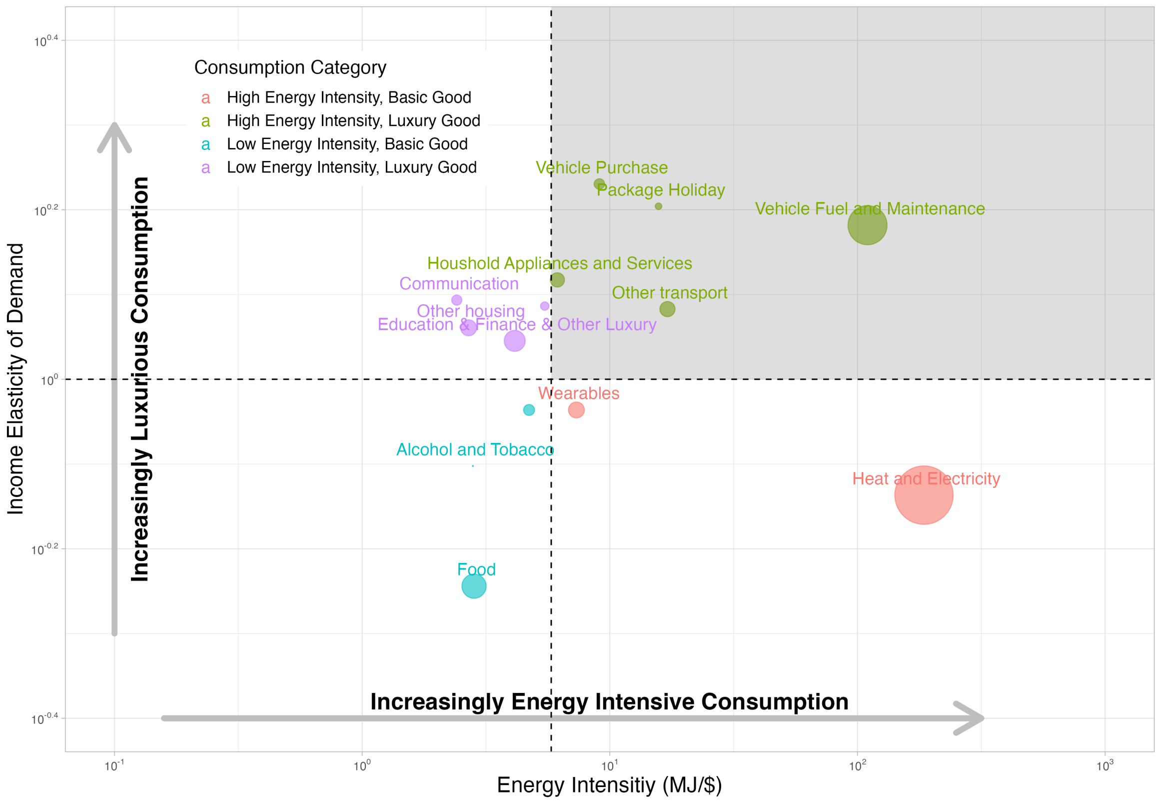

Figure 7: Income elasticity and energy intensity of consumption for different consumption categories in 2011

Notes: The demand for the most energy-intensive consumption goods tends to rise disproportionately with income. This means that on average, a high-income household consumes more energy-intensive goods such as vehicle fuel than a poorer household. **Sources:** Illustration based on data from Oswald, Owen, and Steinberger (2020).

Let us now turn to emissions associated with savings and investments of individuals, rather than to their consumption. When looking at investment-related emissions, it is unsurprising that these emissions play a negligible role for the bottom half of emitters within countries, since this group largely coincides with the poorest half of the population which barely owns any wealth at all, and represent just a tiny fraction of aggregate savings. Put differently, since investments are highly concentrated among the wealthy, it is to be expected that the embodied greenhouse gases do not play a major role in the emissions of the bottom groups. As for the top emitters, investment-related emissions represent a significant part of their total carbon emissions, the question is by how much? There is no perfect methodology to account for this given little available data. According to Chancel (2022) emissions associated with individuals' investments in capital formation (i.e. the construction of machines, factory buildings, etc.) account for at least as much as consumption-related emissions within the global top 1% of emitters.

It is also found that there has been a rise in this share for the top 10% and the top 1% of global emitters in recent decades, which can be traced back to increasing wealth inequalities during the same period and a rising overall share of emissions from investments. As wealth becomes more concentrated within a small group of the global population, this group of the population also concentrates more emissions associated with wealth ownership and investments, thereby increasing the share of the related CO2 equivalents in their total emissions. Here again, we stress that there can be different ways to monitor wealth-related emissions inequalities and we call for more work on the topic to improve existing estimates. Whatever the methodology chosen however, given the extreme concentration of wealth ownership within countries and across the globe, investment-related emissions estimates are also very concentrated, at least significantly more than household consumption-related emissions which already exhibit notable levels of inequalities.

Focus: Emissions of multinationals

What are the emissions of large multinational companies? Several studies have tried to look into this question. The Carbon Major Project, for instance, has looked at emissions of oil majors since the industrial revolution. The project finds that 100 firms account for 71% of global industrial GHG emissions since the industrial revolution (Griffin and Heede, 2017). In this view, however, absolutely all emissions associated with the fossil fuels extracted by those firms are attributed to them. While this provides an interesting and useful perspective on emissions responsibility, the attribution standard also raises important questions: certainly, carbon majors play a large role in climate change, but should we argue that these firms are the only actors responsible for it? Other methodologies have looked into the carbon footprint of multinationals' supply chains, beyond the fossil-fuel industry. Overall, carbon emissions embodied in the supply chains of foreign affiliates of MNEs reached about 6Gt CO2 in 2016, that is nearly 20% of the global total. That year, the carbon footprints of multinationals foreign affiliates originating in the EU totalled around 2.1Gt, followed by the US (1.3Gt) and Hong Kong (1Gt). The footprint of certain large multinationals can be compared to that of some countries: it has been found, for instance, that Coca-Cola's carbon footprint is almost equivalent to Chinese emissions created by the whole food sector (which feeds about 1.3 billion individuals). Walmart's emissions are higher than the emissions of Germanys entire retail sector (Zhang et al., 2020). Here again, such results can help structure public debates on emissions responsibilities; they shed light, for example, on the role of multinational supply chains in driving emissions upwards or downwards. Obviously, MNEs have a key role to play in the energy transition and their capacity to relocate production in countries with poor environmental standards can jeopardise efforts made at home. In section 3 of this report, we make some recommendations for the imposition of levies on multinationals operating in low- and middle-income countries and the investment of such revenues in climate policies of those countries.

While multinationals play a key role in global emissions, it is also important to note that when carbon accounting methodologies attribute emissions to firms, they must not, at the same time, attribute the same emissions to consumers (otherwise responsibilities are attributed twice for the same tonne of carbon and global carbon budgets double). While it may make sense to attribute all responsibility to firm, such a view also has its limitations. Consumers are not entirely powerless in the energy transition: they can change certain production patterns of firms, by shifting from a product to another, for example. In addition, it should be noted that firms are not autonomous entities operating without human intervention: they belong to shareholders who hold the ultimate power over their strategic decisions. Put differently, there are individuals behind multinationals activities, either as consumers or as investors. The method developed by Chancel (2022) seeks to provide a relatively more balanced view of inequality in emissions, taking into account individuals' responsibilities as both consumers and investors (in multinational or other firms) to promote dialogue between those approaches who focus solely on consumers and those who hold producers responsible for all emissions instead. The bottom line is that it is important to look at all available estimates critically given the variety of possible approaches.

1.5. Ending global poverty need not overshoot global carbon budgets

Recent advances in climate inequality research paint a relatively clear picture of the global distribution of carbon emissions. The lifestyles of a relatively small group of the global population directly or indirectly cause the lion's share of global greenhouse gases and are thus largely responsible for the degree of global warming we see today. While cross-country emission inequalities remain sizeable, this pattern of unequal emission shares across population groups is mostly driven by within-country inequalities in emissions. These results naturally raise questions with regard to equity and global justice. The fact that income and emissions are relatively strongly correlated has fuelled arguments claiming that economic development and poverty eradication efforts put further pressure on the remaining carbon budgets by increasing the consumption of the poor.

Restructuring current energy use could significantly alleviate multidimensional poverty. Recent research contradicts the idea that ending global poverty would eat up most of the remaining global carbon budgets, by showing that lifting large numbers of people out of poverty need not have a large negative effect on climate change mitigation. Kikstra et al. (2021) show that current energy consumption in all areas of the world is significantly greater than the energy that would be required to provide decent living standards for the entire global population. The authors estimate the amount of energy that would be needed to provide a decent living for everyone in terms of nutrition, shelter, health, mobility and socialisation in 2050, based on country-specific requirements for 193 countries.[6] Their results suggest that current global energy consumption is almost three times higher than the energy that would be required to meet such basic needs for all (see Figure 8). Yet, in most regions of the world, energy use does not primarily serve the purpose of satisfying basic needs. Only in North America and Western Europe is the current energy deployed for the provision of decent living standards theoretically sufficient to meet the basic needs of the entire population. In all other regions, insufficient energy is currently used to provide for basic needs. This is particularly true for low-income regions such as Sub-Saharan Africa where the lack of energy provision for decent living goes hand in hand with extremely

[6] Decent living standards are derived from various sources for each category. For nutrition, for instance, the authors use minimum dietary energy requirements from the Food and Agriculture Organization of the United Nations and then translate these into the energy needed for the production, preparation and storage of the minimum number of calories depending on the local conditions in each country.

low overall energy use. By contrast, in other regions, overall energy use is significantly above the level required to provide decent living standards, but only a small fraction of total energy is used to this end. This is even more true from a global perspective, since merely one fourth of current energy is used for basic needs provision at the global level. Kikstra et al. (2021) project that in 2050, the energy required for the provision of decent living standards will represent between 23% and 28% of global energy consumption (based on energy projections under SSP2). In other words, their results suggest that eradicating multidimensional poverty does not necessarily require a massive expansion of global energy consumption. Instead, considerable progress could be achieved by restructuring current energy use and curbing demand at the top of the distribution.

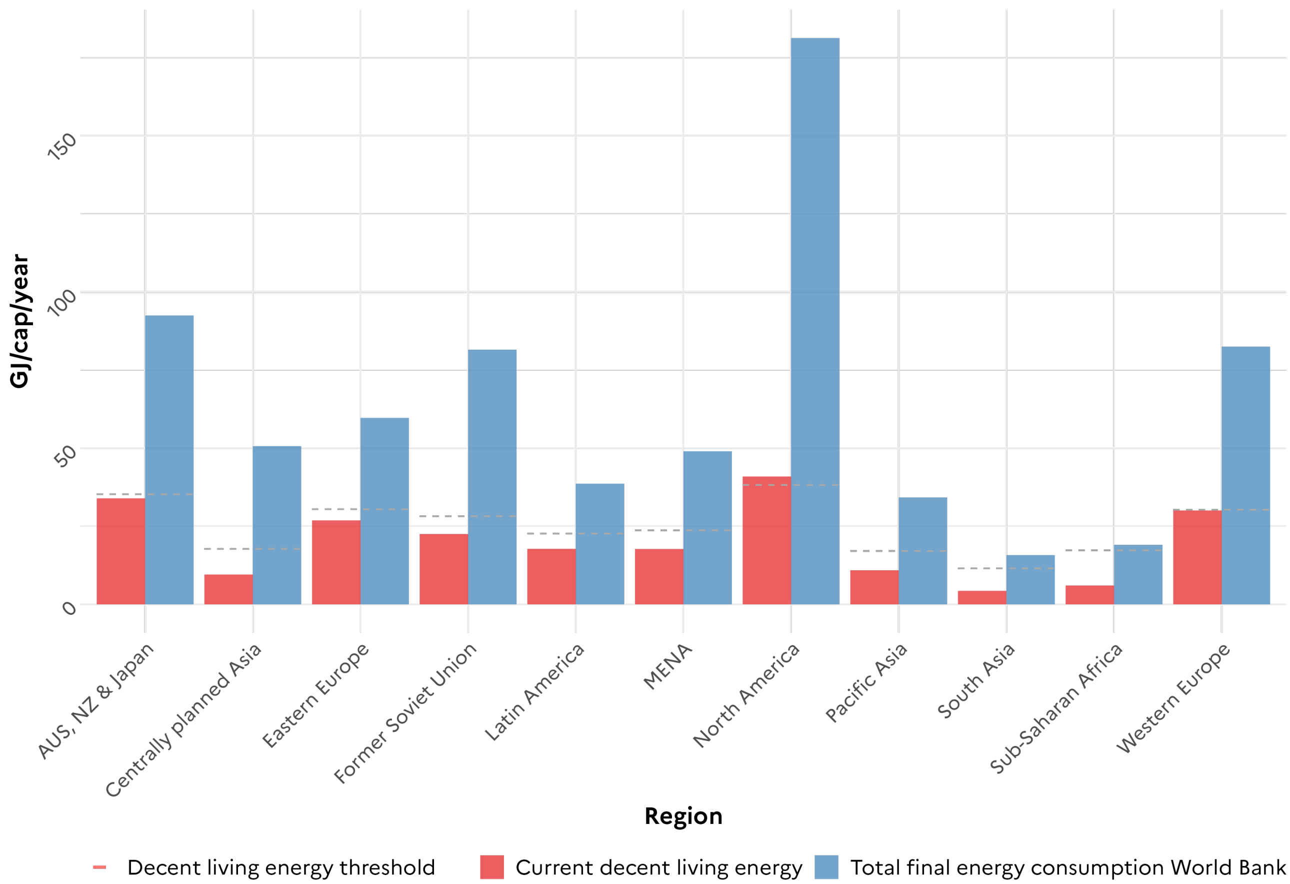

Figure 8: Current total energy and share of this energy used for DLS provision vs projected energy needs for universal DLS in 2050

Notes: Current energy consumption in most world regions exceeds the amount of energy theoretically required to provide universal decent living standards to all. This is true in particular for high-income regions. However, the share of total energy actually deployed for the provision of decent living standards is small in most regions. Therefore, redistributing energy use would make it possible to increase living standards for large population segments without increasing total energy consumption. **Sources:** Figure based on Fig. 4a from Kikstra et al. (2021).

Poverty alleviation and climate change mitigation efforts can be combined through redistribution. Another recent study by Oswald, Steinberger, et al. (2021) also finds that lifting billions of people out of energy poverty need not put a large strain on the remaining carbon budget. The authors start from the observation that energy use and income are strongly linked, and then analyse the effects of reducing income inequality on energy consumption using a simplified model of the global income distribution. Their results suggest that considerably reducing the share of people in energy poverty (from currently 60% to 10%) would only moderately increase global energy consumption by 6.7%. In their model, this sizeable reduction of energy poverty is achieved through a significant redistribution of income on the global scale. They find that the share of people in energy poverty is strictly increasing in the degree of economic inequality as measured by the spread of the global income distribution. Energy poverty begins to drop significantly at a standard deviation of approximately US$10,000 which is also the level where no mega-consumers (whose consumption is defined as equal to that of the top 20% of US Americans in 2011) exist. The model results further suggest that, to achieve poverty eradication at US$1.9 through redistribution from the top, top global incomes would need to be cut at US$467,000 per year which would imply redistributing from no more than 0.1% of the world population. For more ambitious poverty definitions, the share of top incomes that would have to be redistributed increases but never exceeds 11.6% given the model's assumptions. Hence, the general conclusion that considerably reducing energy poverty would not necessarily entail a large increase in carbon emissions if it were accompanied by redistributive policies appears robust.

Carbon budgets required for poverty eradication are small compared with top emitter footprints. Bruckner et al. (2022) explicitly estimate the effect of different poverty eradication scenarios on global carbon emissions using 2011 World Bank expenditure survey data for 116 countries. Based on disaggregated information on the expenditure patterns of different income groups in different regions, they model a range of scenarios where the poorest population groups are shifted into higher expenditure bins above varying national or international poverty lines. Their results suggest that lifting the whole world's population above the poverty line of US$3.20 a day would increase global carbon emissions by less than 5%. These estimates are based on the assumption that the observed expenditure patterns would remain the same within expenditure groups under the counterfactual poverty alleviation scenarios. While it is probable that such large-scale interventions would induce some broader general equilibrium effects that might result in changing consumption and expenditure patterns, the estimates provide an idea of the order of magnitude of the carbon effect of tackling global poverty. The authors further estimate that eradicating global poverty below US$5.50 would entail an increase in carbon emissions of approximately 18%. Such an effort would be synonymous with significant improvements in living standards for almost half of the global population. While an increase in carbon emissions of 18% may appear sizeable, it is crucial to put these numbers into perspective. Bruckner et al. (2022) estimate that the top 1% of global emitters are responsible for 15% of global emissions and thus only marginally smaller than the amount of carbon required to shift everyone above the poverty line. In other words, the extra carbon budget required to eradicate global poverty at US$5.50 and improve the livelihoods of more than three billion people is comparable to the emissions currently generated by the global top 1%. Focusing on the top 10% of global carbon emitters, the required carbon budget for ambitious poverty alleviation comprises roughly a third of their current emissions. The implications of these results are clear: global poverty alleviation is difficult, but is neither out of reach nor heavily constrained by climate change mitigation. If global top emitters were to make their fair share of climate change mitigation efforts, and emissions were significantly cut at the top, sufficient carbon budgets would be freed up to lift the entire world population above a poverty threshold of US$5.50 a day. Let us stress that eradicating global poverty does not directly translate into the creation of an affluent middle class: at US$5.5 per day, individuals are not well-of by global standards. In that sense, the development of an affluent global middle class within planetary boundaries will not be possible simply via the redistribution of "carbon space" from the global top 10% to the rest of the global population. Such a redistribution will help a lot but aggressive mitigation policies in low and middle income countries, coupled with the development of a new model of low-carbon middle-class prosperity in these countries, is also paramount.

Reducing multi-dimensional poverty and providing decent living standards for all while remaining within ecological limits raises significant distributional questions but is not an unattainable goal per se. Vogel et al. (2021) investigate which institutional conditions can facilitate the satisfaction of human needs at low energy requirements. They leverage data on the level of satisfaction of six basic needs (health, nutrition, drinking water and sanitation access, education, and minimum income) and energy use for 106 coun-

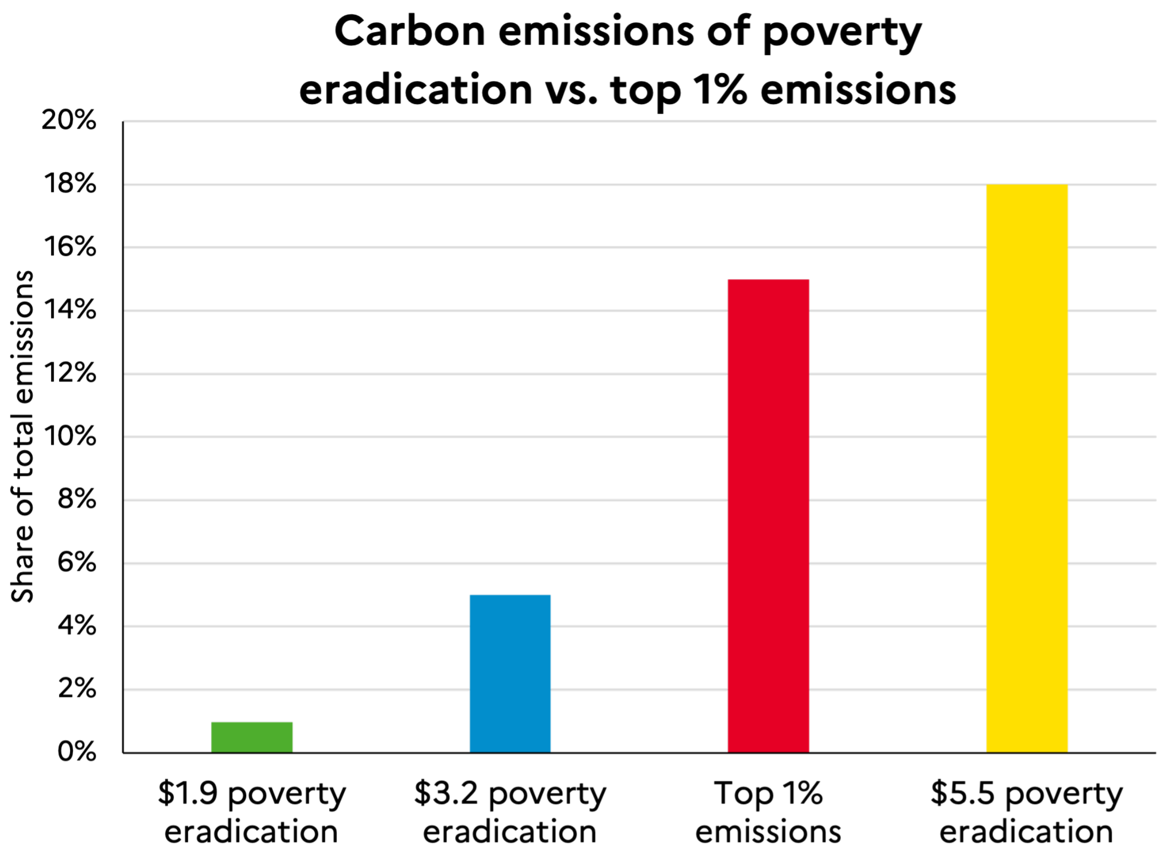

Figure 9: Additional carbon emissions of different poverty alleviation scenarios vs. emission from global top 1% according to Bruckner et al. (2022)

Notes: Eradicating global poverty would not entail a large increase in carbon emissions. Lifting the entire global population above the poverty line of US$3.20 a day would increase current carbon emissions by less than 5%. A more ambitious poverty eradication scenario of shifting everyone above the US$5.50 poverty line would increase emissions by 18%. That is, the carbon budgets required for global poverty eradication are broadly comparable to those consumed by the top 1% globally. Note that the top 1% share estimate is similar but not exactly equal to the value reported in Figure 3, due to different methodologies mobilized. **Sources:** Figure based on data from Fig. 5 in Bruckner et al. (2022).

tries in order to identify socio-economic arrangements that would allow a high level of needs satisfaction at comparatively low energy use. They show that countries with comparatively high-quality public services and infrastructure, high income equality, and universal access to electricity are most successful at meeting the needs of their population at relatively low levels of energy use. While these are complex relationships and the estimates provided by the authors do not identify causal effects, they provide important insights into the most promising institutional structures for sustainable development.

Bringing together the results of all the studies cited here, it seems that climate change mitigation and the universal satisfaction of human needs are far from being mutually exclusive goals. As the remainder of this report shows, they are in fact two sides of the same coin for an inclusive and sustainable development agenda.

2. Unequal impacts of climate change

2.1. Unequal exposure to extreme weather events

Global warming has begun to noticeably influence the frequency and severity of extreme weather events including extreme heatwaves and droughts, as well as extended periods of extreme precipitation and flooding. However, these effects do not materialize in the same way or to the same extent around the world. While temperature variability tends to decrease in high latitudes, a 1°C increase in the global mean temperature is associated with a 15% rise in temperature variability by the end of the century in regions such as Amazonia and Southern Africa. Bathiany et al. (2018) show that poor countries, which bear little responsibility for global warming will face the strongest changes in temperature variability. In other words, low income countries will see themselves exposed to more volatile temperatures and more frequent temperature anomalies with potentially devastating effects on agricultural output, while regions with the highest responsibility for climate change may experience reduced temperature volatility.

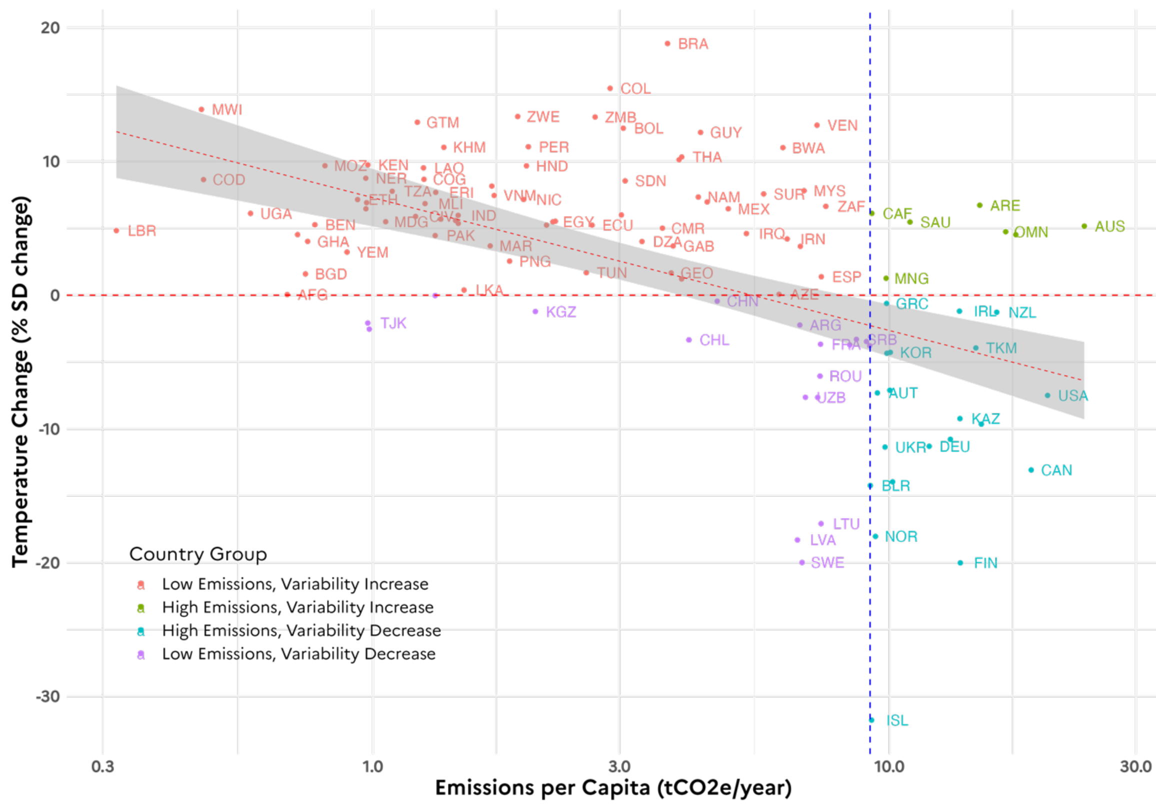

Figure 10: Predicted change in temperature variability until end of century vs emissions per capita between 1990 and 2013

Notes: There is a negative correlation between predicted changes in temperature variability and greenhouse gas emissions. On average, countries with comparatively low per capita emissions will experience stronger changes in temperature variability. Those countries that bear the highest responsibility for observed climate change tend to face moderate changes or variability reductions. **Sources:** Authors based on Fig 5b. from Bathiany et al. (2018)

Technical box: Compound Events

Many climate hazards are not independent from each other but often share common climatic drivers. This means that certain hazards are more likely to occur simultaneously in time and space than if they were independent events. Such a combined occurrence of multiple climate drivers and hazards whose interaction aggravates their impacts on social and environmental systems is referred to as compound event (Zscheischler et al., 2018). Such events can form complex and cascading risks and render adaptation significantly more challenging. Such complex events are also likely to affect and exacerbate existing challenges in human systems. Zimbabwe, for example, was hit by a severe drought and heatwave in the summer of 2020 while trying to contain the spread of Covid-19 in the country. The drought immediately put millions of people at risk of food and water insecurity thereby increasing the pressure on public health authorities through malnutrition and disease caused by lack of safe water access. Adding to this, the heat wave led to excess heat-related mortality. At the same time, the drought caused power cuts in many southern African countries due to outages in hydro-power generation which limited the capacity of public infrastructure to respond to the crisis. Food and water insecurity further triggered migration and displacement in some regions, which further complicated the containment of the pandemic, thus adding to the public health burden (Phillips et al., 2020). This example shows how compound events can pose multifaceted challenges to human systems and illustrates the need for a better understanding of such events in order to develop suitable policy responses and adaptation strategies.

Changing climatic conditions pose a serious risk to food security. What does the increased occurrence of extreme weather events mean for the affected populations and their livelihoods? Food security is a major concern in the face of aggravating climate conditions in many areas of the world. Anthropogenic climate change has already put a significant strain on the world's agricultural production: recent estimates based on global data suggest that current total factor productivity (that is, the overall productivity of a sector, or how much is produced relative to the resources it uses) in the agricultural sector is approximately 20% lower than in a counterfactual scenario of no climate change (Ortiz-Bobea et al., 2021). While this constitutes a considerable average productivity impact at the global level, there is also considerable regional heterogeneity in the effects of climate change on agricultural production. Figure 11 illustrates this by showing the disaggregated effects across continents and countries. It is clear from the graph that some regions have incurred much stronger negative impacts than the global average. In Africa, for instance, average agricultural productivity is estimated to be almost 35% below its potential value in the absence of climate change. While some countries, such as Canada or Russia, have even seen their agricultural productivity increase as a consequence of climate change, the most extreme adverse effects have materialized in tropical and subtropical countries in Africa and Latin America, such as Mali, Niger, Sudan, Nicaragua, and Guatemala with productivity losses up to 40% due to anthropogenic climate change.

Chapter five of the current IPCC report provides a comprehensive overview of climate change impacts on agriculture and food systems (Bezner Kerr et al., 2022). These impacts are partly attributable to slow-onset mean changes in temperature and precipitation, but also to destruction of crops by extreme weather events and disasters. In 2010, a large flood in Pakistan caused yield losses of US$4.5 billion by directly destroying crops and delaying the planting of new ones. High-income regions in the Global North are not immune to significant agricultural losses either. Brás et al. (2021) estimate that crop losses due to combined heatwaves and droughts have tripled during the last five decades in Europe. Figure 12 summarizes the results of more than 150 studies on the observed effects of changing climatic conditions on agricultural productivity and crop yield around the world. The first column confirms the results by Ortiz-Bobea et al. (2021) and shows that climate change has led agricultural total factor productivity to drop in virtually all regions of the world. The following columns show the breakdown of climate impacts on crop yields for different crop species and categories, and the last column shows the aggregate effect for all crops. The overall picture is unambiguous: climate change has negative effects on the yields for the majority of crops in most regions. Apart from Central Asia, the only area where aggregate yields have increased as a consequence of changing climatic conditions, the effects are either mixed or unambiguously negative. Eleven of 14 regions have already seen negative impacts on aggre-

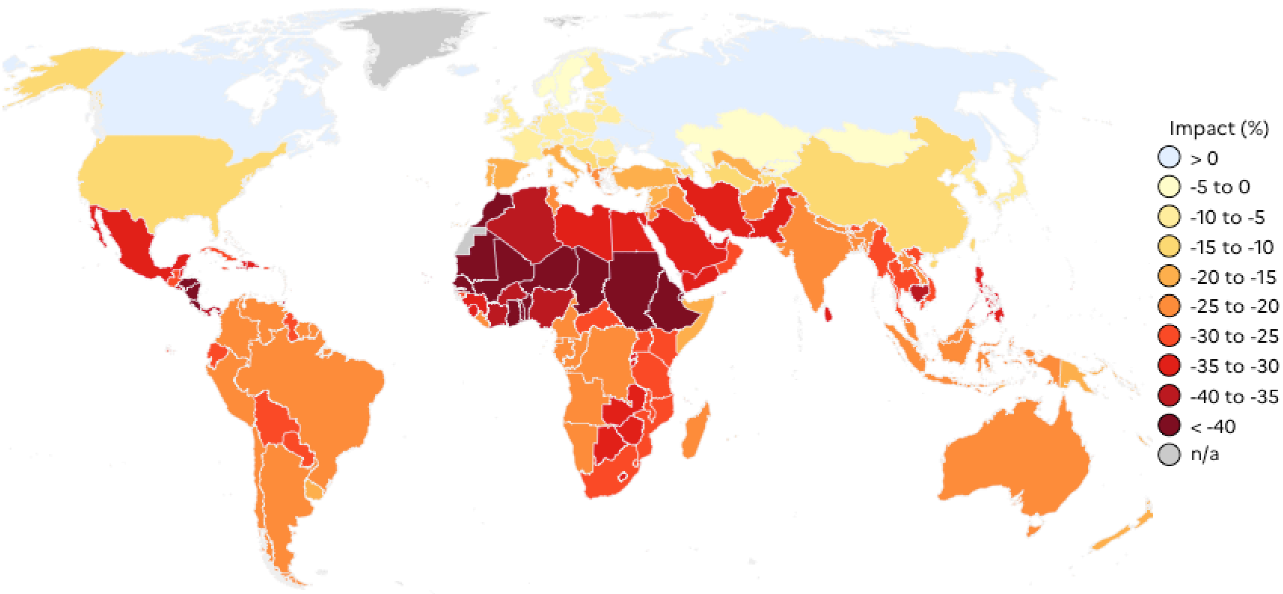

Figure 11: Observed regional effects of climate change on agricultural productivity across the world (1961-2015)

Notes: Some world regions have already incurred agricultural productivity losses of more than 30% due to climate change since 1961 (relative to a world without climate change). These losses are strongest in areas that have contributed little to historical emissions and thus reinforce existing inequalities. **Sources:** Fig. 5 from Ortiz-Bobea et al. (2021).

gate crop yields. Sub-Saharan Africa, for instance, has had to cope with significant yield losses for all crop categories in the recent past. Given that it is also the world region with the highest poverty headcounts and rates of food insecurity, these reduced crop yields aggravate hunger for large numbers of people who depend directly on agricultural incomes or are vulnerable to highly volatile food prices.

Wiebe et al. (2015) estimate that, out of 53 countries that exhibited concerning levels of food security in 2008, climate change has already negatively affected consumable calories in 27 countries, thereby seriously aggravating food insecurity. These impacts are projected to worsen significantly by 2050, as climatic conditions become less and less favourable to the cultivation of an increasing number of crops. The resulting effect here is twofold. First, it directly affects food accessibility on the demand side and sufficient calorie intake through price shocks. Second, a large fraction of the worlds poor depends on income from agricultural production for their livelihoods. Crop failures and yield losses due to climate change thus directly affect the capacity of many people in low-income regions to sustain themselves and their families (Hallegatte, Bangalore, et al., 2016).

A single day at 35°C increases heat-related mortality in sizeable proportions

Aside from agricultural effects, the climate-induced shift in temperature distributions across the globe will directly affect temperature-related mortality. Again, tail events are what matters most in this context. The overall relationship between mortality and temperature follows an inverse U-shaped trajectory. Populations in relatively cold regions will see their mortality risk decrease as climate change shifts the temperature towards higher levels and thus reduces the occurrence of extreme cold-weather events. Conversely, temperature-related mortality is predicted to increase in already warm regions, which intersects with a pattern of country-level income inequality. The aggregate results suggest that a single day at 35°C increases heat-related mortality by 10.1 deaths per 100,000 inhabitants (relative to the minimum mortality temperature, which is dependent on the region). By 2100, these impacts will translate into heat-related mortality rates comparable in magnitude to the mortality effects of all types of cancer today (under RCP8.5). This mortality effect almost exclusively materializes among people aged 64 and older. Hence, countries with relatively high shares of population in this group are likely to encounter higher mortality rates. Within a given region, income is a protective factor against the mortality effects of heat because it increases adaptive capacity, e.g. through air conditioning etc. which implies that excess mortality will be most pronounced

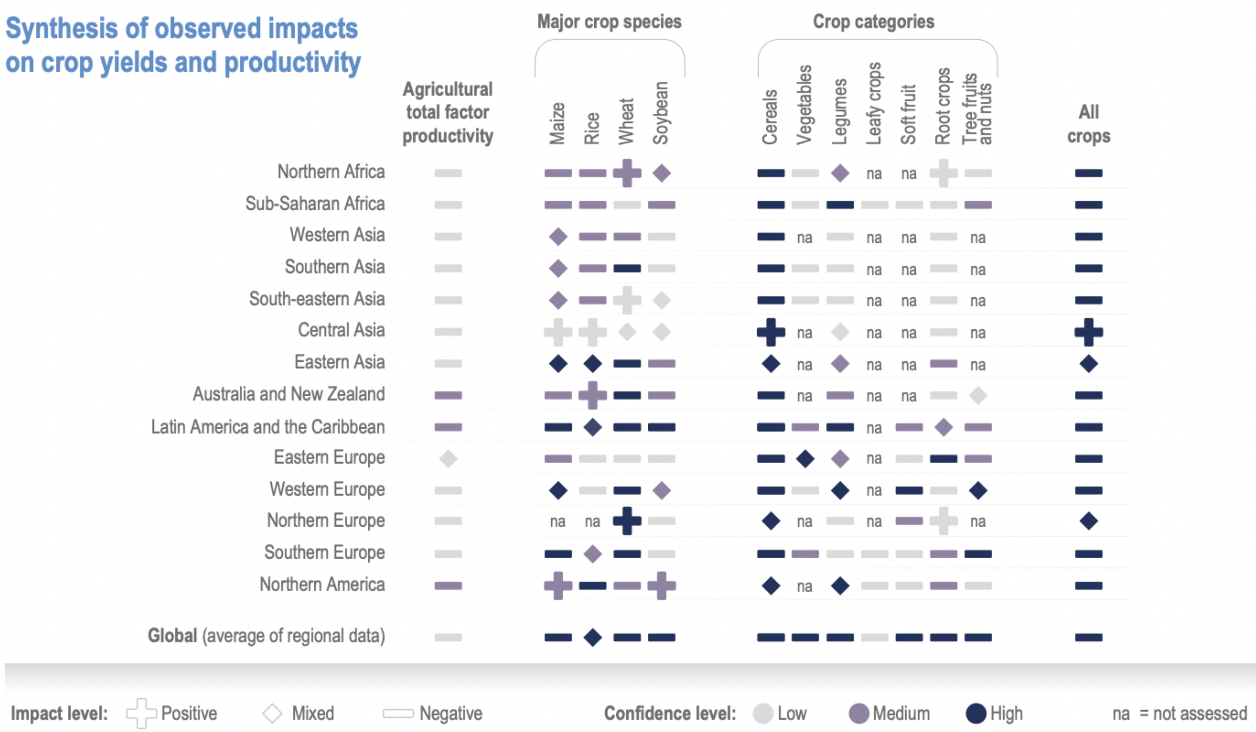

Figure 12: Overview of estimated impacts on crop yield and agricultural productivity from over 150 studies

Notes: There is strong scientific consensus regarding the observed impacts of climate change on agriculture. Overall, the effects are negative for most regions and crops. This is especially true in tropical and subtropical regions. **Sources:** see Fig. 5.3 IPCC (2022)

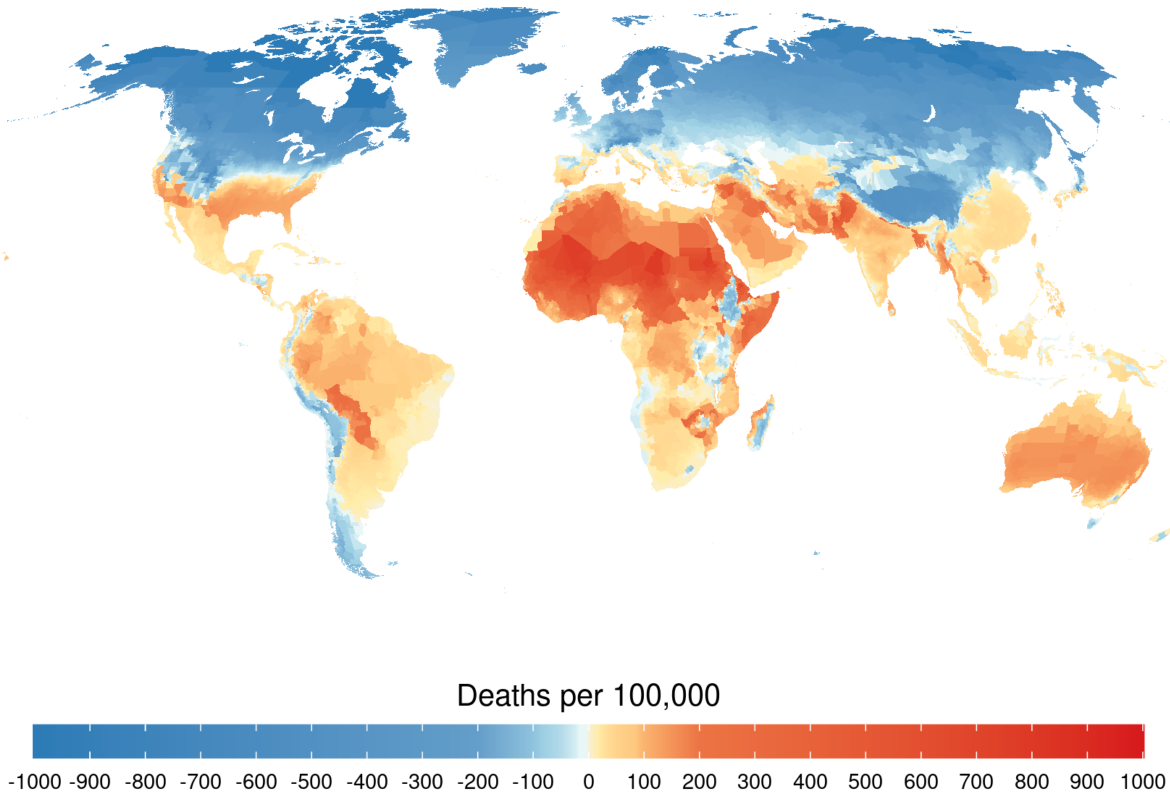

Figure 13: Spatial distribution of predicted heat-related mortality impacts across the world in 2100

Notes: Many regions in the Global South will suffer heavy heat-related mortality increases by 2100. Many high-income countries in the North will experience positive mortality effects due to the reduced occurrence of extreme cold temperatures. **Sources:** Fig. 4 from Carleton et al. (2022).

among low-income groups (Carleton et al., 2022). Detailed mortality data by country can be accessed on the UNDP Human Climate Horizons platform (UNDP, 2022a), along with data on other forms of climate impacts.

2.2. Unequal exposure to rising sea levels and floods

Between 1902 and 2015, the mean global sea level rose by 0.16m. This rise was mostly driven by the melting of land ice and ice sheets, and to a lesser extent by thermal expansion of ocean water. The current pace of change is unprecedented over the last century. The rate of increase from 2006 to 2015 was 2.5 times faster than the rise observed from 1901 to 1990. This acceleration is driven by the increasingly rapid loss of ice mass from the Antarctic and Greenland sheets, which is taking place at an unforeseen pace. Ice-mass loss from the Antarctic sheet was three times faster between 2007 and 2016 than in the preceding decade. It is critical to note that a mean sea-level rise of 0.16m at the global level translates into strongly heterogeneous effects in different coastal areas and can lead to extreme coastal sea levels in certain regions, depending on various factors such as tidal forces, wave run-up, and wind (Caretta et al., 2022).

At the global level, poor people are disproportionately exposed to rising sea levels. Rentschler, Salhab, and Jafino (2022) estimate that globally, 1.8 billion people are exposed to serious flood risk (all types of flooding, i.e. including fluvial and pluvial) and would face inundation depths of 0.15m or more in the case of a 1-in-100-year flood event. This corresponds to roughly 23% of the world population being at considerable risk of flooding. In absolute terms, China and India have the highest headcounts of flood exposure due to their large population size and long coastlines. Nine of the ten countries most exposed to significant risk of flooding (see Figure 14) are low-income or middle-income countries. The tenth, the Netherlands, has the highest share of population at risk, but it benefits from protection systems equipped to cope with more severe disasters than 1-in-100-year flooding events. This is not the case for the other countries listed here. At a subnational level (ADM-1), the share of population at risk increases to over 80% in certain regions (e.g. in the Pool region in the DRC and the Red River Delta in Vietnam). The regions exposed to serious flood risk account for US$9.8 trillion of economic activity, which is equivalent to roughly 12% of global GDP (in 2020) being exposed to significant flood hazards. Of the 1.81 billion people at flood risk, 780 million live below the US$5.5 poverty line. Hence, roughly 43% of the people

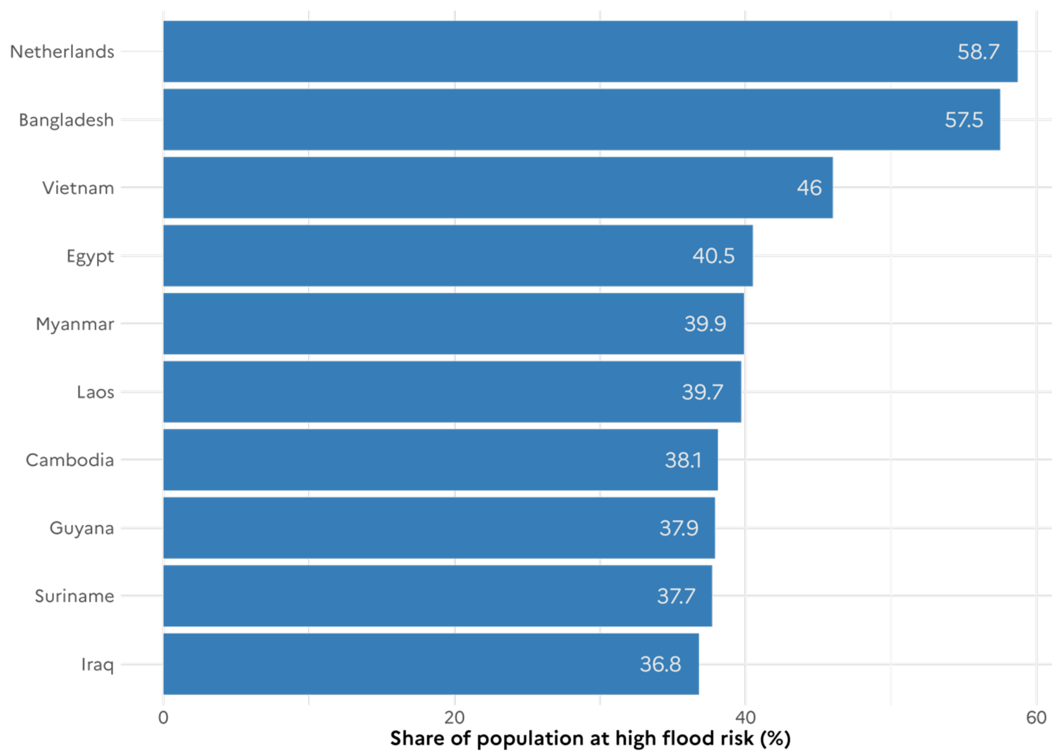

Figure 14: Share of population exposed to significant flood risk, top 10 countries with the highest exposure share in 2020

Notes: Nine of the ten countries with the highest population share at significant flood risk are low- and middle-income countries. In some countries, including Bangladesh, more than half of the population is exposed to significant risk of flooding - often with insufficient protective measures. **Sources:** Fig. 3b from Rentschler, Salhab, and Jafino (2022).

at flood risk are exposed to poverty at the same time, which is known to seriously reduce adaptive capacity and recovery after natural disasters.The overlap between poverty and flood risk is largest in Sub-Saharan Africa where 28% of the population are exposed to both burdens (using US$5.5/day as poverty definition). Figure 15 maps the population share exposed simultaneously to significant flood risks and poverty at the sub-national level. Sub-Saharan Africa and South East Asia clearly stand out as the two regions with the highest combined risks of flooding and poverty.

Even under moderate climate change, risks of flood may exceed current levels by up to three orders of magnitude. In future predictions, expected long-term sea level rise is very sensitive to the emission scenario and likely to continue beyond the end of the century. Under RCP8.5, the global mean sea level will rise by several metres, while this could be limited to approximately 1m under RCP2.6 (IPCC, 2022). These projections significantly exceed those made in previous IPCC reports due to the increased speed of ice mass loss from the Antarctic sheet. Even under RCP2.6 and a comparatively moderate sea level rise, flood risks will increase significantly by the end of the century, exceeding current risks by up to three orders of magnitude (IPCC, 2022).

By 2050, many small islands and coastal areas will be exposed to annual flooding events that were previously expected to occur just once in a century. The difference in flood-related costs at the end of the century between a 1.5°C scenario and disastrous climate change under RCP8.5 is estimated to be US$14.3 trillion per year (Jevrejeva et al., 2018). The greatest absolute damage is predicted to occur in countries in the upper-middle income group of countries, mainly driven by China because of its long coastline and large coastal population. The countries with the highest relative GDP loss due to flood damages are Kuwait (24%), Bahrain (11%), UAE (9%) and Vietnam (7%). As Figure 16 illustrates, effective adaptation measures have the capacity to drastically limit flood related losses. Conversely, failure to implement effective adaptation measures rapidly, in particular for the most exposed and vulnerable, will directly cause increasing death rates as well as billions of dollars of additional losses.

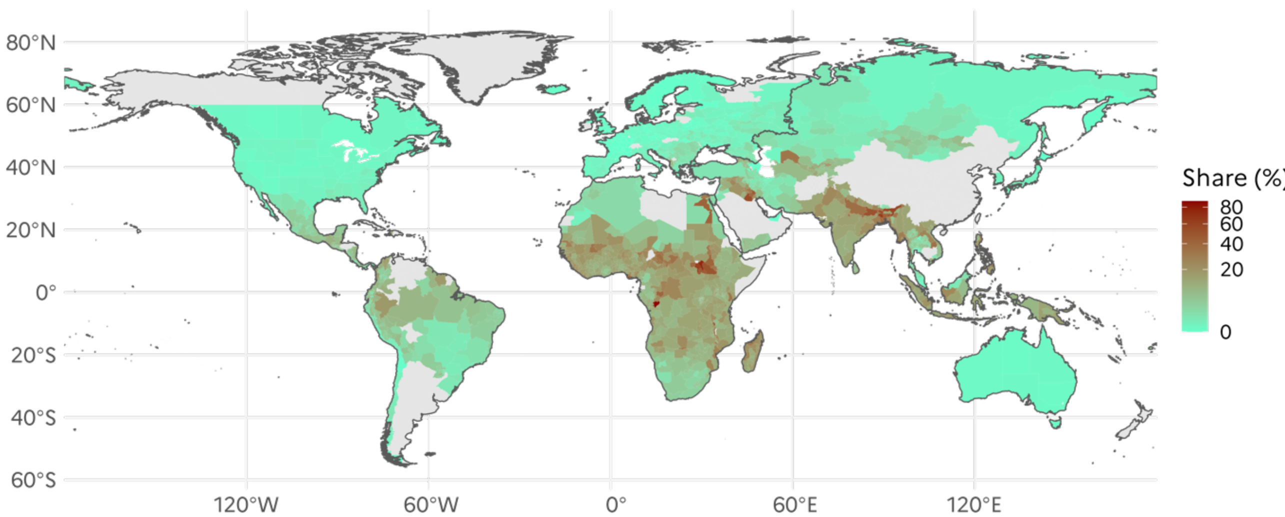

Figure 15: Population share exposed to significant flood risk and poverty (using $5.5/day poverty line) across the world in 2020

Notes: In many low-income regions, sizeable fractions of the population are exposed to the multi-faceted risks of poverty and flooding simultaneously. Poverty reduces the capacity to adapt and react to natural disasters thus making the overlap between poverty and flood risk a major threat for the most affected regions. **Sources:** Illustration based on Rentschler, Salhab, and Jafino (2022).

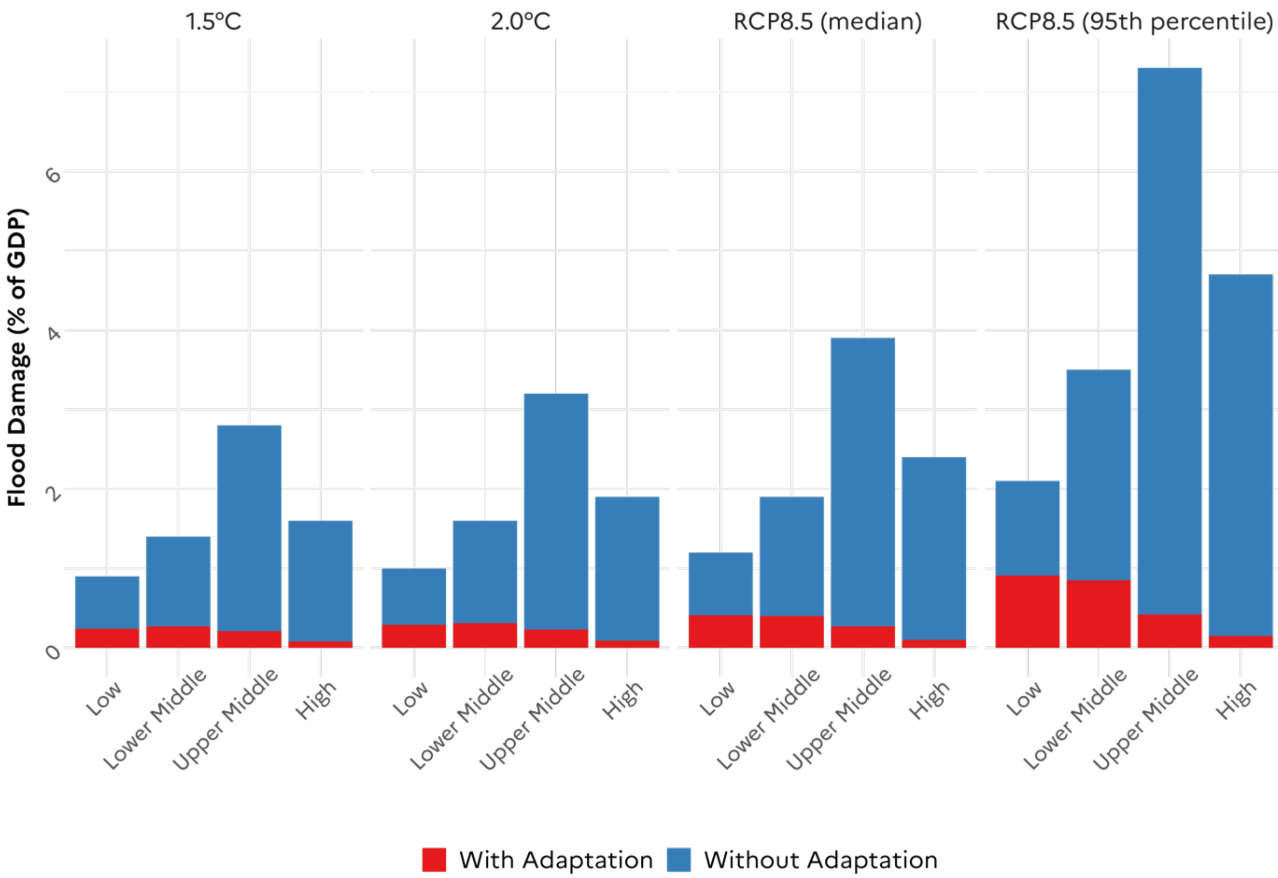

Figure 16: Annual flood cost/GDP ratio with and without additional adaptation under different climate scenarios (Projected impacts in 2100)

Notes: Without additional mitigation and adaptive measures, recurring floods will cause damage worth more than 5% of GDP in some regions every year. High- and upper middle-income countries have the capacity to reduce damages significantly through adaptation programs, whereas low-income countries will incur high annual losses even with additional adaptation. Bars represent World Bank country income categories. **Sources:** see Fig. 6 Jevrejeva et al. (2018).

2.3. Unequal exposure to diseases

In poor countries, the risk of malaria has increased significantly due to climate change. The transmissibility of many infectious diseases is sensitive to climate conditions. Global warming has led to increased propagation of climate-sensitive diseases in many parts of the world. The spread of illnesses such as dengue fever and the zika virus has already increased significantly due to changing climatic conditions. Romanello et al. (2021) estimate that the R0 of diseases[7] such as dengue and zika was 7%-13% higher in the period 2010-2019 than in the baseline period 1950-54. Similarly, increasing average temperatures have made conditions more favourable to malaria transmission. This has induced a temporal and spatial expansion of malaria infections. Figure 17 shows that the number of months in a year conducive to malaria transmission has significantly increased in the group of low HDI countries, which is mostly linked to the geographical location of most of the countries in this group. No changes were observed in the countries with high and very high HDI, which suggests that malaria prevention and eradication will become increasingly difficult and put an additional strain on public health in the most deprived regions of the world. At the same time, changing climatic conditions have made certain regions not previously affected by malaria suitable to its transmission. That is, a geographical expansion of malaria has been observed on top of the increased prevalence in already endemic areas (Cissé et al., 2022).

[7] The R0 is the average number of cases of an infectious disease arising by transmission from a single infected individual.

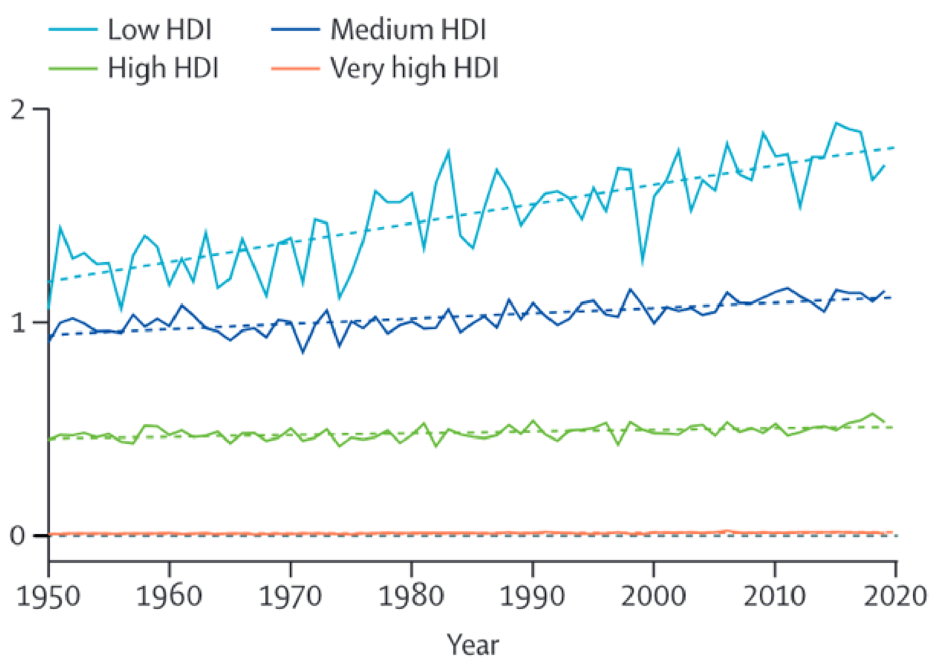

Figure 17: Average number of months suitable for malaria transmission 1950-2020 by country group

Notes: Changing climatic conditions have put a strain on malaria eradication efforts by increasing the number of months conducive to its spread in the group of countries low on the Human Development Index. Climate change thus increases the disease burden and public health challenges in the most affected regions. **Sources:** see Fig 8b Romanello et al. (2021).

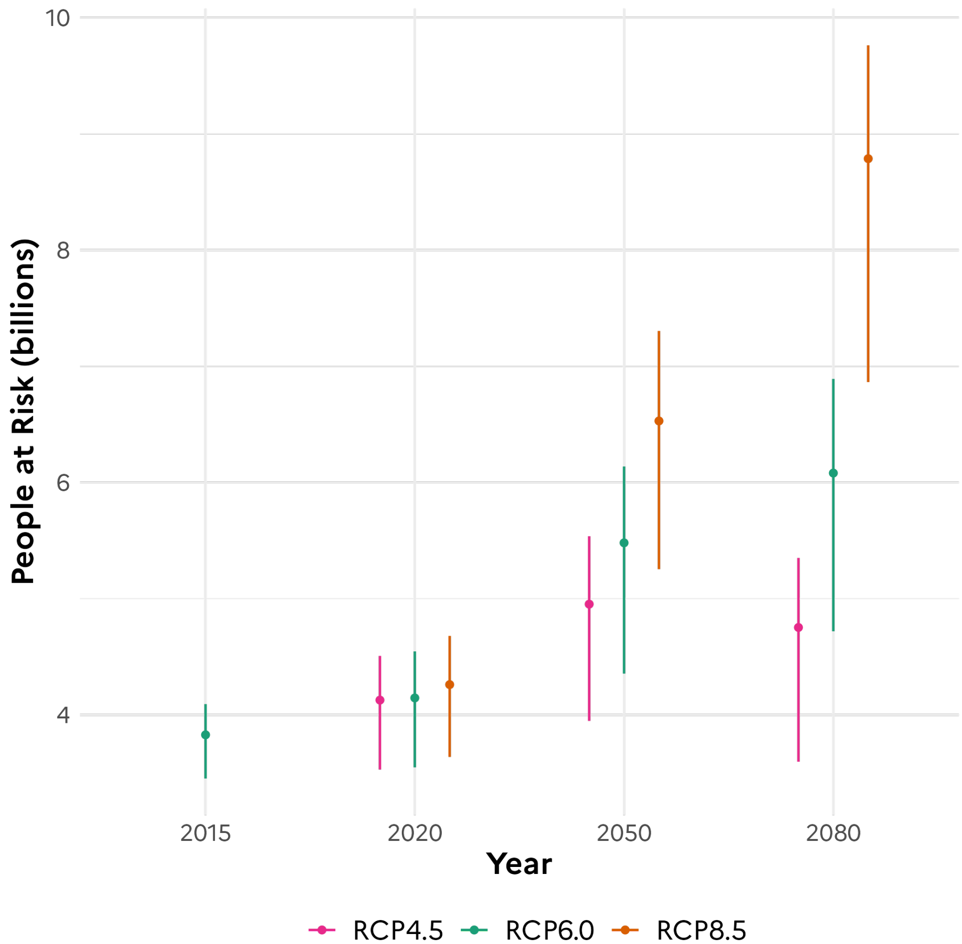

Figure 18: Predicted number of people at risk of dengue globally by climate pathways

Notes: The number of people at future risk of contracting dengue is highly sensitive to climate conditions. Under escalating climate change, dengue prevalence will increase significantly in already endemic areas and spread geographically to currently unaffected regions, thereby potentially affecting billions more people. **Sources:** see Fig. 2c Messina, Brady, and Golding (2019).

Tropical diseases will continue to spread in low-income regions of the world

Projections suggest that the trend of increased incidence of climate-sensitive diseases will continue to aggravate in the decades to come, but the severity and extent of increased disease occurrence strongly depends on the emissions scenario. Messina, Brady, and Golding (2019) predict that an additional 2.25 billion people may be at significant risk of contracting dengue in 2080 compared to 2015 (under RCP 6.0 and SSP2). This is due to improving living conditions for the vectors of the disease (mainly so-called *Aedes* mosquitos) under ongoing global warming. The increased propagation is mainly driven by an intensification in areas where dengue occurrence is already relatively high today, and to a lesser extent by geographical spread. Since the incidence is high today mostly in tropical/subtropical regions, the extra health burden will fall on these areas, coinciding with currently comparatively low incomes and low public health expenditure. Figure 18 shows the predicted number of additional people affected as a function of climate scenarios. While the outlook is grim for high-emissions scenarios, there is a chance of limiting the spread to much more moderate levels if more ambitious mitigation actions are undertaken.

Poverty multiplies the effect of climate change on diseases like cholera

Rising sea surface temperatures and more frequent flooding also contribute to an increase in the prevalence of water-borne diseases such as cholera. While conditions for the transmissibility of water-borne diseases differ around the world, cholera is transmitted through food or water contaminated with specific bacteria (Caminade, Mcintyre, and Jones, 2019). Hence, sanitation and access to safe drinking water are key to limiting outbreaks following natural disasters (Jutla, Khan, and Colwell, 2017). Therefore, low-income regions with poor sanitation infrastructure are at increased risk of cholera outbreaks as a consequence of climatic hazards. This relationship also illustrates the interplay of different climate impacts. As changes in temperature and precipitation affect water safety and availability, the capacity to react to natural disasters and to contain outbreaks of water-borne diseases is severely impeded.

Suicide rates likely to increase with climate change, in particular among the worst off

Climate change has also been shown to have negative effects on mental health. These include direct effects such as post traumatic stress disorder in people exposed to natural disasters and extreme weather events, indirect effects, such as mental health problems caused by climate-related malnutrition, and vicarious effects such as depression and anxiety about future climate risks (Helm et al., 2018; Hock et al., 2018; Obradovich et al., 2018). Burke, González, et al. (2018) estimate that a 1°C increase in monthly average temperatures increases suicide rates by 0.7% in the US and by 2.1% in Mexico. Figure 19 extrapolates this relationship to predict the number of excess suicides that will be exclusively attributable to mean temperature changes in the US in 2050 under the RCP8.5 scenario. The median projection for the US amounts to roughly 14,000 additional suicides caused by changes in mean monthly temperature. These estimates do not include the effects of rapid-onset events such as natural disasters, which can have dramatic immediate effects on mental health among the affected populations. Given that access to air cooling and other protection against heat-waves is also known to be correlated with social status, it is very likely that a disproportionate toll of these losses will be borne by low-income groups among the affected population.

Obradovich et al., 2018 compare a general indicator of mental health of US citizens who were affected by Hurricane Katrina in 2005 with those who were not affected. Their estimates suggest that the probability of reporting mental health problems increased by roughly 4% for individuals affected by the hurricane. In addition to the direct effects of an extreme event like Katrina, the authors also investigate the mental health effect of gradual changes such as temperature increases. Their estimates suggest that average maximum temperatures above 30°C lead to a significant increase in reported mental health issues of more than one percentage point relative to temperatures at 10°C - 15°C. These effects are not homogenous across population groups but affect low-income individuals and women more strongly, as these groups tend to have reduced capacity to protect themselves from the adverse impacts of extreme temperatures. Research on the mental health impacts of climate change is relatively limited for low-income countries, but a review of 17 studies for South American and Asian countries found an increased prevalence of PTSD, anxiety and depressive disorder following extreme weather events in all countries with some events inducing

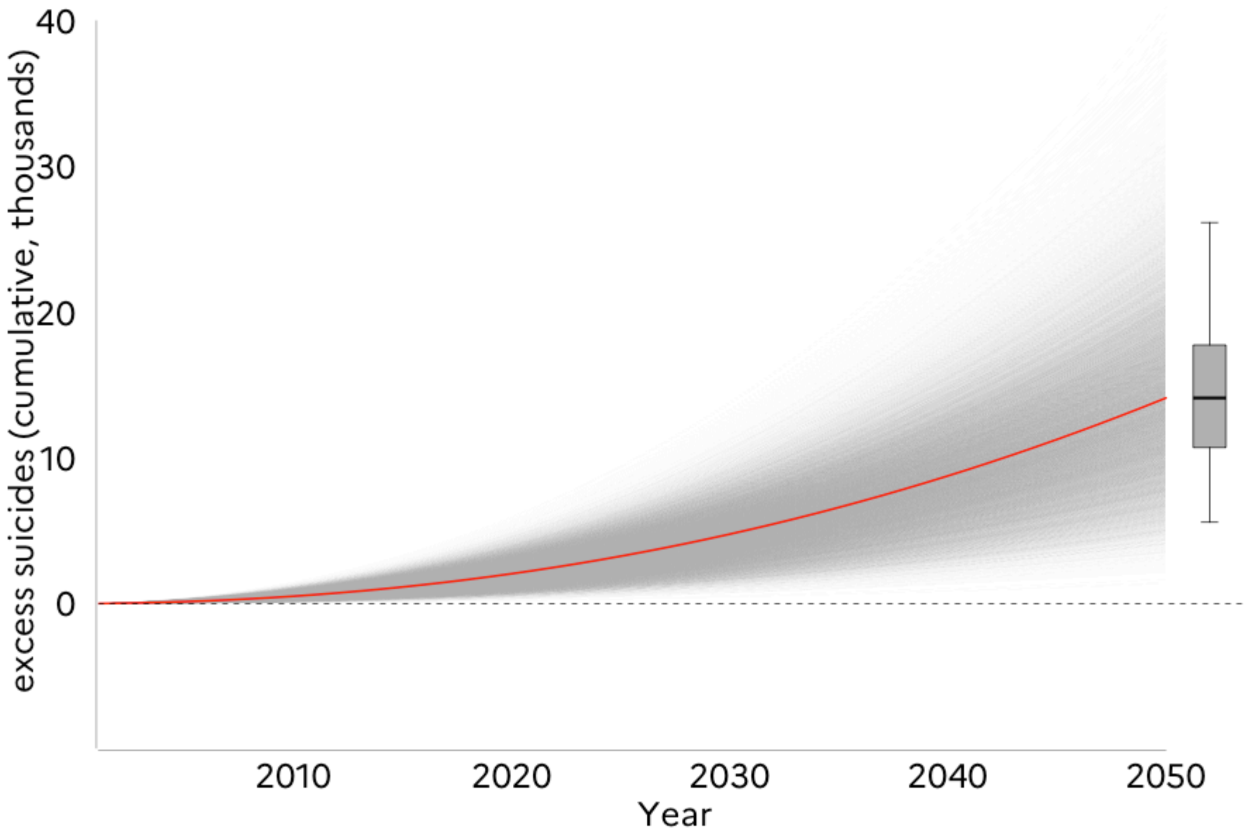

Figure 19: Projected excess suicides due to temperature change in the US by 2050

Notes: Climate change is likely to cause a substantial increase in suicide rates in the US. If unmitigated, changing temperatures are likely to be responsible for more than 10,000 additional suicides in the US by 2050. **Sources:** Authors based on Fig. 5 Burke, González, et al. (2018).

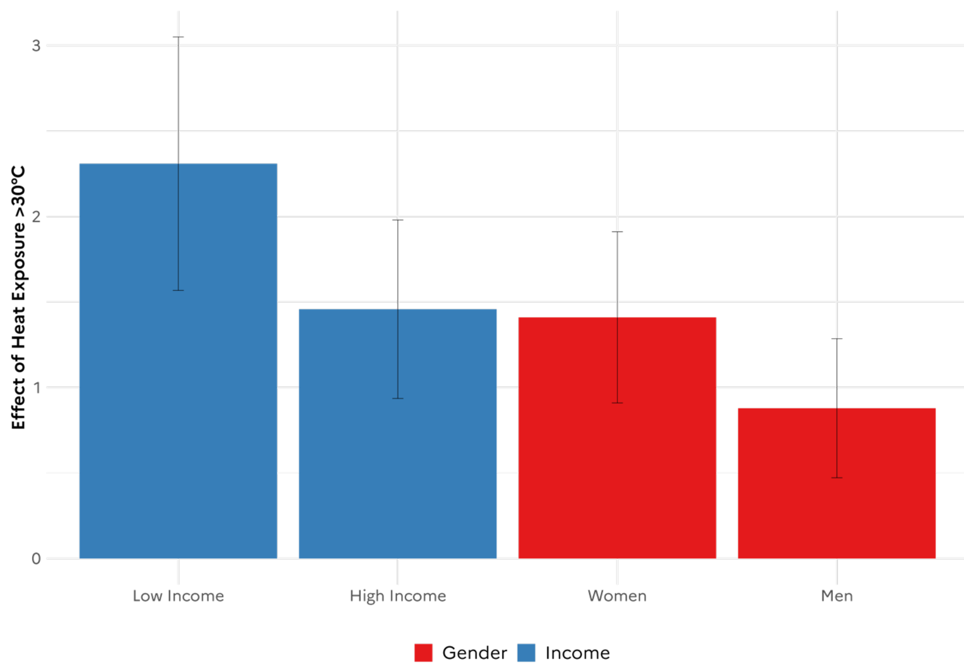

Figure 20: The climate-income-gender inequality nexus: unequal effects of heat exposure on mental health in the US

Notes: The mental health effects of extreme temperatures are heterogeneous across gender and income groups. Women and poor people tend to suffer more from mental health effects than men and more affluent individuals on average. Bars represent the marginal effect of heat exposure (>30°C) on the probability of reporting mental health issues (in percentage points).**Sources:** see Fig. 2 Obradovich et al. (2018)

dramatic surges of more than 40% in PTSD prevalence Rataj, Kunzweiler, and Garthus-Niegel (2016).

2.4. GDP losses: climate change aggravates between-country inequality

The relationship between temperature and GDP seems to be inverse U-shaped. Hence, relatively cold/temperate countries (typically high-income today) may profit to some extent from climate change while low-income countries in warm regions will incur significant and increasing losses.

Climate change has already exacerbated inequalities between countries. What do its impacts on economic production mean for between-country inequality? Diffenbaugh and Burke (2019) provide an answer to this question by constructing a *counterfactual income path*, i.e. an estimate of national GDP per capita levels that would be realized today had climate change not affected the economic system. These income estimates are based on climate model projections and represent hypothetical income levels, but can be used to quantify the economic effects of climate change. The general pattern is that high-latitude countries have benefited from anthropogenic climate change in terms of historical output gains, while low-latitude countries, i.e. largely those with mean temperatures above the optimum (see below for an explanation) have already incurred significant losses. In other words, many low-income countries of the Global South are significantly poorer today than they would be in the absence of anthropogenic climate change to which most of them have contributed very little. At the same time, many rich countries in the Global North that bear the largest responsibility for climate change have even benefited in income terms. This pattern is illustrated in Figure 21 which shows the differences in GDP between the hypothetical scenario without climate change and the observed reality. Many poor countries with negligible historical emission shares would be significantly better off today had the economic elites in the Global North abstained from the extractive processes of production and wealth generation based on fossil fuels that largely persist today. Consequently, the current level of inequality between countries is also higher than in the counterfactual scenario of no climate change. Diffenbaugh and Burke (2019) estimate that the income ratio of the countries at the 90th and the 10th percentile of global GDP distribution is 45% greater today than it would have been in the absence of climate change. In short, anthropogenic climate change has already aggravated

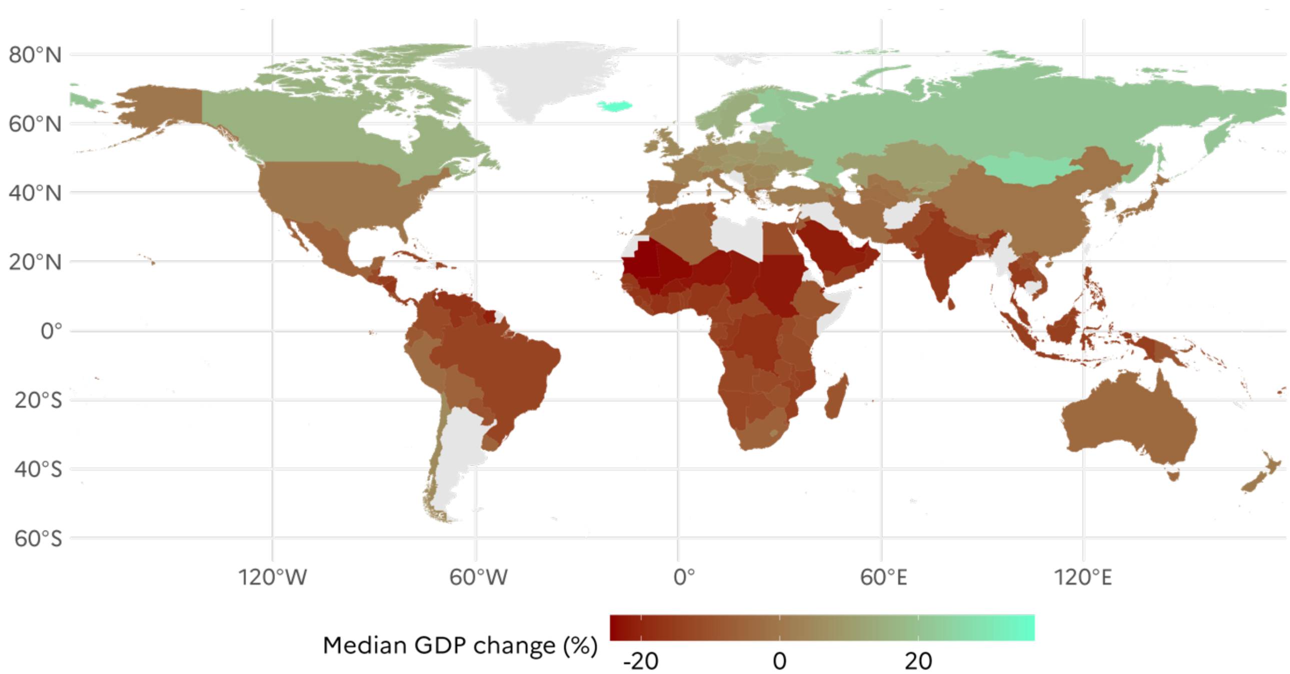

Figure 21: GDP change relative to no climate change scenario 1991-2010

Notes: Climate change has increased between-country economic inequality by negatively affecting economic development in tropical and subtropical areas. As countries in these latitudes are already relatively poorer than most countries in higher latitudes, who bear the most responsibility for historical emissions, climate change has increased the income gaps between rich and poor countries. **Sources:** Authors based on Fig. 2AB Diffenbaugh and Burke (2019) global inequality and remains a serious impediment to equitable development and a global convergence of living standards.

In the future, subtropical and tropical countries will experience large GDP losses thereby increasing between-country inequalities. The negative effects of climate change on global inequality will extend into the future and will exacerbate existing development challenges. Burke, Hsiang, and Miguel (2015) find the relationship between economic output and temperature to be inverse U-shaped in a sample of 166 countries for the period between 1960 and 2010. The optimal temperature for maximizing income is estimated to be around 13°C annual mean temperature. This suggests that for countries that have mean temperatures below this level, climate change may be beneficial for GDP growth to some extent, while countries that exhibit higher mean temperatures are already incurring significant losses. As most countries above the turning point are low-income or low- to middle-income, unfolding global warming is likely to further aggravate existing inequalities. Figure 22 shows this by comparing projected income levels with and without climate change in 2100. The left-hand side shows the national GDP estimates in the presence of climate change while the right-hand side shows the projections in its absence. The spread in income levels is considerably wider in the presence of climate change, an effect that we can trace back to the GDP-temperature relationship described above. As some temperate countries see their productivity increase under global warming, so do their GDP levels, while many subtropical and tropical countries face significant output losses due to global warming. For an in-depth discussion of the impacts of climate change on inequality between countries, and of the impact of modelling assumptions on these results, interested readers may refer to Taconet, Méjean, and Guivarch, 2020.

The effects of increased rainfall on growth are non-linear. The two aforementioned studies focus on the effects of temperature on economic production. Kotz, Levermann, and Wenz (2022) complement these insights by estimating the impacts of rainfall changes on economic growth rates for a sample of 77 countries subdivided into 1,554 regions. They combine information on GDP growth rates at the sub-national level with rainfall data for the period 1979-2019 to assess the impacts of changes in different precipitation measures on output growth. They find a positive but decreasing effect of total annual rainfall on average output growth. In other words, increased precipitation leads to higher growth rates, especially when total annual rainfall is low,

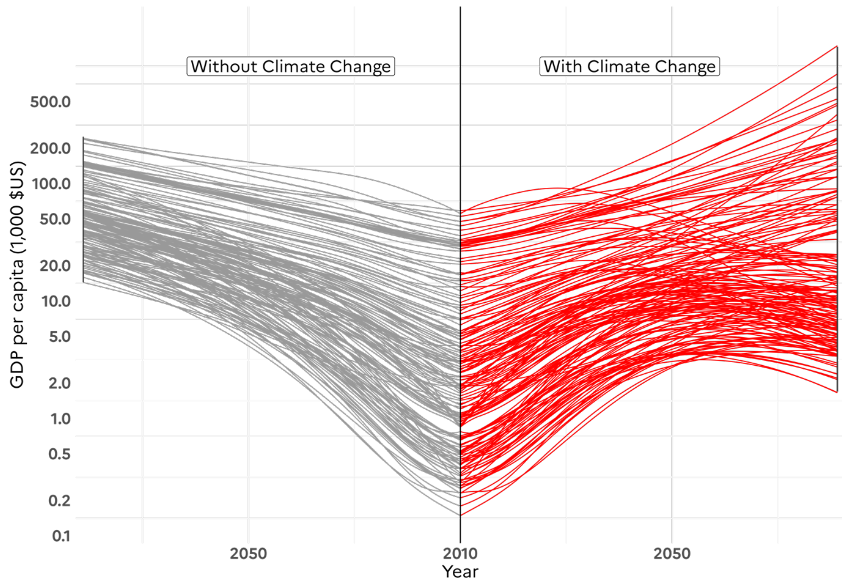

Figure 22: GDP projections by 2100 across the world with and without climate change

Notes: The impacts of climate change on production will further increase income inequality between countries this century (right-hand side of the graph) as compared to future without climate change (left-hand side). **Sources:** see Fig. 3 Burke, Hsiang, and Miguel (2015).

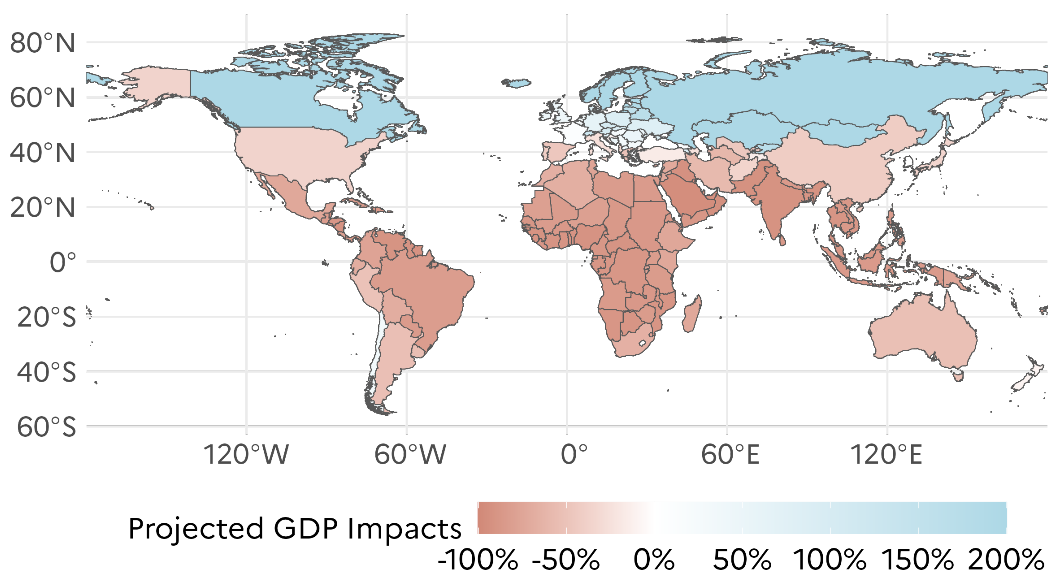

Figure 23: Change in GDP per capita by 2100 attributable to climate change

Notes: Projected GDP impacts by 2100 attributable to climate change are mostly concentrated in low and middle income countries. **Sources:** based on data from Burke, Hsiang, and Miguel (2015).

but has little effect at higher levels of annual rainfall. Interestingly, the relationship between monthly rainfall deviations and income growth is inverse U-shaped but asymmetric. Negative deviations from the historical mean of monthly rainfall (i.e. droughts) have strong negative effects on economic growth, while positive deviations have insignificant effects. This is illustrated in Figure 24. It can be seen that strong negative deviations from the long-term mean can significantly hinder economic growth. Some of the dry periods observed in the data are associated with a drop in output growth rates of more than two percentage points. The results further suggest that the frequency and intensity of extreme rainfall have strong negative effects on growth. The estimated effects are relatively symmetrical for low- and high-income countries but strong precipitation changes are much more likely to occur at lower latitudes so that the effects materialize more heavily in those regions. Indeed, rainfall variability is highest in Central Africa in the data that Kotz, Levermann, and Wenz (2022) use, so the cumulative effects on growth rates are also likely to be strongest here. Hence, it appears that, like the effects of temperature on economic production, low-income countries are not necessarily more sensitive to changing climatic conditions per se but face more severe impacts on growth due to higher exposure to climate hazards.

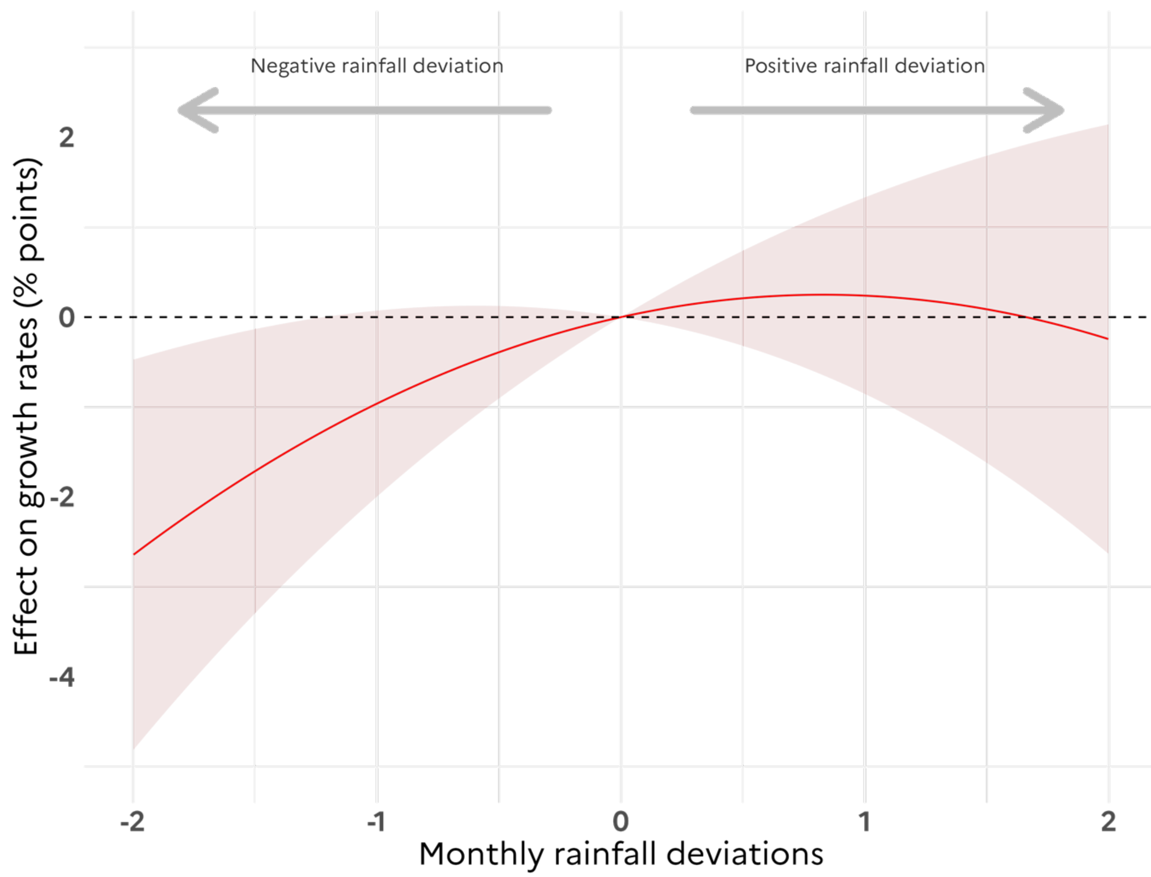

Figure 24: Effect of monthly rainfall deviation on economic growth based on data from 77 countries (1901-2014)

Notes: Negative rainfall shocks (droughts) have strong negative effects on economic growth rates. As severe droughts are most likely to occur in low income regions, this mechanism will also aggravate between-country inequality. **Sources:** see Fig. 2b Kotz, Levermann, and Wenz (2022).

2.5. Exposure, vulnerability and resilience: the distribution of climate damage

The impact of climate hazards on well-being critically depend on the vulnerability and resilience of individuals and communities. The previous sections have mainly discussed inequalities and the effects of climate change at the international level. While these differences reflect an important dimension of climate injustice around the world, there are additional layers of inequality, within countries and regions. Within any given country or geographical area that is exposed to climate change impacts, such as extreme weather events, not all people are equally exposed and equally vulnerable to the effects of these events.

Figure 25 illustrates a framework developed by the World Bank for conceptualizing losses from climate impacts, which focuses on climate-related well-being losses (Hallegatte, Vogt-Schilb, et al., 2017).[8] These losses are determined by several factors. The first and most evident is the nature and severity of the hazard, for example, the intensity and duration of a heatwave. The introduction of this report stressed that both the frequency and intensity of climate-related hazards are already increasing in many regions and will continue to do so at an accelerating pace. Therefore, a growing number of people will experience climate hazards more and more frequently in coming years. Previous sections of this chapter have demonstrated that exposure to such hazards is extremely unequally distributed across the world. Often, this is also the case within countries, where poor populations live in more exposed areas (e.g. in poorly protected coastal regions) or are likely to work in jobs associated with higher exposure (e.g. agricultural work is often linked to greater heat stress). These differences in exposure constitute the second dimension in determining the well-being losses from climate hazards. Third, different population groups exhibit differing degrees of vulnerability when exposed to hazards. The reasons for this are manifold. For instance, low-income housing tends to be of poorer quality and thus more prone to storm and flood damage. The poor also typically hold more material and spatially concentrated assets (e.g. livestock) than the non-poor. This means that even when exposed to the same hazard, different income groups will not incur the same damage. The final dimension used to determine well-being losses, by Hallegatte, Vogt-Schilb, et al. (2017), is called socio-economic resilience and refers to the capacity of households to cope with the damage incurred. This capacity is determined by the interplay of

[8] For an overview of the different conceptual approaches to analyze environmental inequalities, see also (Laurent, 2020; Martinez-Alier, 2003) among (many) others.

Figure 25: A well-being-centred concept of climate losses

Notes: Losses in well-being caused by climate hazards are a function of exposure to the hazard, vulnerability to its impacts, and capacity to adapt to and recover from it (socio-economic resilience). This last dimension distinguishes a well-being-centred concept of climate losses from a purely asset-based approach. **Sources:** Fig. 0.1 Hallegatte, Vogt-Schilb, et al. (2017).

numerous variables. To what extent does a household's livelihood depend on the assets affected by the disaster? How directly is their consumption linked to income sources affected? Do they have savings, insurance policies, financial assets, or other forms of wealth that can buffer the impact of the shock? How well are they covered by social security and other social safety nets? Here, too, inequalities exist, and they are key to understanding the resilience of people when hit by a disaster.

Taken together, the four dimensions explained above form a complex mechanism that determines the impact of climate hazards on well-being. This approach contrasts with the usual estimation of disaster-related asset losses. A simple quantification of total asset losses cannot take into account differences in capacity to cope with shocks. By incorporating a dimension of socio-economic resilience into the framework, it may thus be possible to obtain a more comprehensive picture of the damage caused by climate hazards. The following section investigates inequalities in each of the dimensions that determine well-being losses separately in order to understand better how and why different income groups in the same regions do not face the same climate-related threats.

85% of the population from a large sam-

ple of countries live in places where poor people are overexposed to droughts. The previous sections have outlined unequal exposure to different types of hazards across countries. Regarding the within-country dimension of exposure inequality, Hallegatte, Bangalore, et al. (2016) investigate whether poor people are overexposed to three types of climate change hazards (droughts, floods and heat stress) by estimating a poverty exposure bias defined as the ratio of the poor's exposure to the exposure of the overall population, in 52 countries. Their results suggest that in most cases, poor households tend to be more exposed to climate change effects than the non-poor. This bias is particularly strong for droughts. Of the population analysed, 85% lived in places where poor people are overexposed to drought events. Regarding extreme temperatures, the poverty exposure bias was found to be particularly strong in countries that already exhibit comparatively hot temperatures. In other words, their estimates suggest that overexposure of poor people is most pronounced precisely where temperature impacts are likely to be most severe. In a study of a 2014 heatwave in Portland, Oregon Voelkel et al. (2018) also find that low-income and non-white households were more likely to live in neighbourhoods that suffered from the most extreme temperatures. Mahadevia et al. (2020) studied temperature differences between formal and informal housing during the hottest months of the year 2016 in Ahmedabad, India. They find the average temperature difference between formal and informal housing during the summer months to be 7.6°C. This can be attributed to poor ventilation and commonly used corrugated iron roofs of informal housing as well as high residential density in areas with a high proportion of informal housing. While the study does not explicitly distinguish between income levels, there is no doubt that low-income groups are more likely to live in informal dwellings so that the temperature differential for housing types is likely to translate into differential exposure of income groups. Furthermore, informal dwellings often lack access to safe drinking water, which can significantly aggravate the health consequences of heat exposure. Such inequality in exposure to extreme temperatures is robustly linked to a higher number of heat-related deaths among low-income groups. Carleton et al. (2022) estimate that compared with a day at 20°C, a day at 35°C causes 4.7 extra deaths per 100,000 people at the global average among those aged 64 and older. The disproportionate exposure of deprived households to the most extreme temperatures means that they bear the greatest share of this mortality burden.

Low-income households are typically more exposed than high-income households. Overexposure of low-income groups to environmental risks has also been documented for other types of hazards. Narloch and Bangalore (2018) analyse the association between household consumption and exposure to eight different environmental hazards, including floods, temperature and rainfall variability, and droughts, in Vietnam. They find that for most environmental hazards, low-income households face higher risks and exposure than more affluent households. The authors also find that households in areas with higher precipitation variability have significantly lower consumption levels on average. This is particularly true for rural households. Their panel estimates also suggest that increased rainfall variability has a significant negative effect on the consumption levels of the poor, which illustrates a vicious circle associated with exposure inequalities. The disproportionate exposure of low-income populations to environmental hazards as such is a major challenge for equitable development, but it also perpetuates the economic situation of the most affected and thus aggravates existing inequalities by locking or pushing people into poverty. In summary, there is thus little doubt that there is an association between exposure to climatic hazards and income, and that the over-exposure of the poor poses major risks to their lives and livelihoods in many cases.

When hit by severe weather events, low-income populations are affected more strongly than others. Low-income populations are not only more exposed to climate change hazards but also tend to be more severely affected when hit by them. Patankar (2019) analyses extreme precipitation events in Mumbai, Chennai, and Puri District in India between 2005 and 2015. Mumbai experienced unprecedented extreme precipitation and a subsequent flood disaster on 26 July 2005, with estimated losses of up to US$5 billion. While almost the entire city incurred heavy losses caused by the floods, Patankar (2019) shows that the burden was not equally distributed among socio-economic groups and that the poor were more vulnerable. In her sample of 1,168 households surveyed after this disaster, the estimated repair and replacement costs exceeded the monthly income of the most deprived group by a factor of almost 15. In comparison, the cost incurred by the higher-medium income group was roughly equal to one monthly income. The extreme events in Chennai and Puri District had similar devastating consequences. These variations in relative damage are of course partially attributable to low incomes in the denominator of such ratios for the poor, but this is not the whole picture. Deprived populations also live in poor-quality housing and therefore incur greater relative damage to their dwellings when struck by floods. Also, the assets held by the poor are often material and thus more prone to be affected by natural disasters. High-income groups on the contrary often hold spatially dispersed or intangible assets, which provide a buffer against severe income losses. These groups derive smaller shares of their livelihoods from assets or activities that are directly and physically affected, thus the structure of their incomes and wealth means that they are typically better protected from the worst economic consequences of climate hazards than lower income groups.

Income sources and consumption baskets explain why poor people are the first losers from climate events in the developing world. Poor people also tend to rely to a larger extent on agricultural incomes and ecosystem services for their livelihoods and are thus more prone to climate-induced income shocks that affect these income sources. High-income households on the contrary are less likely to derive labour income from sectors imminently affected by natural disasters, generally relying less on labour income for their livelihoods. Similarly, poor people spend a much larger fraction of their income on food and other basic necessities and are thus more severely affected by food and energy price shocks following natural disasters. Thus, while absolute losses in incomes and assets are larger among more wealthy households, due simply to the higher value of their assets, poor households suffer larger relative losses. Hallegatte and Rozenberg (2017) use household surveys from 92 developing countries to estimate the distribution of climate-related income losses by 2030. Figure 26 plots the predicted average income losses for different scenarios in all 92 countries against the estimated income losses of the bottom 40%. If there were no vulnerability difference between low-income households and the average, the fitted line should be close to the 45° line which represents equal losses. A slope parameter larger than unity, as estimated here, indicates that the relative losses faced by the poor exceed the average losses within a given country. Precisely, the results presented by Hallegatte and Rozenberg (2017) suggest that overall, the relative income losses of the poorest 40% will be 70% greater than those of the average population. This increased vulnerability of the poor also threatens poverty alleviation efforts as climate-induced income losses may push millions of additional people into extreme poverty, mostly due to higher food prices, agricultural output losses, and adverse health effects.

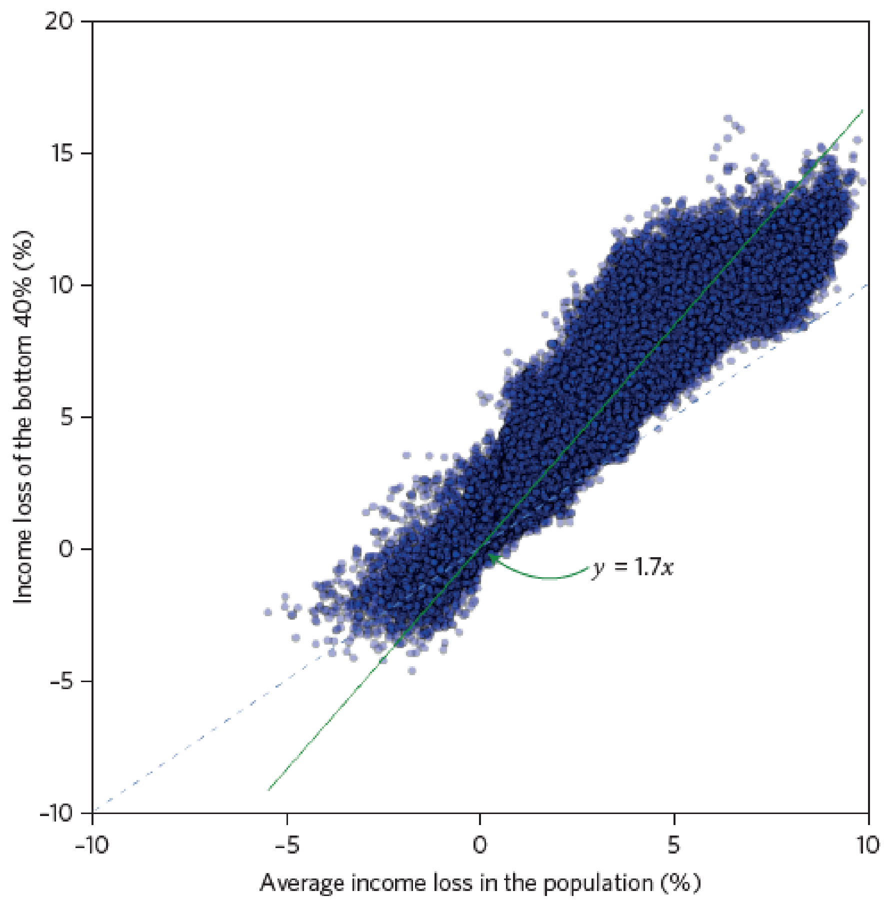

Figure 26: Climate-induced income loss for poorest 40% vs average loss based on household surveys from 92 countries

Notes: When affected by climate hazards, the bottom 40% in the national income distribution tend to incur losses that are 70% higher than the population average. Climate change thus also aggravates within-country inequality through this channel. **Sources:** Fig. 5 from Hallegatte and Rozenberg (2017)

Low-income groups in high-income regions also disproportionately affected.

The pattern of increased vulnerability of low-income groups also appears to hold for climate-related disasters in higher income regions. A recent World Bank report points out that the relative consumption losses from earthquakes and flooding also strictly decrease with income levels in Europe and Central Asia (World Bank, 2021). In a country like Greece, for instance, the average loss in consumption from flooding (and earthquakes) for the poorest part of the population exceeds the loss incurred by the middle class by approximately a factor of 4. Hence, even in relatively wealthy countries, the distribution of climate impacts and their severity are strongly related to income. This is also the conclusion reached by Osberghaus and Abeling (2022) about the vulnerability of low-income households to heat stress in Germany. Based on a sample of more than 10,000 households they analyse whether economically deprived households (defined as having equivalized household income below 60% of the median) are more exposed and sensitive to heat stress. While there appears to be no exposure gap, i.e. low-income households do not live in areas where heat stress is particularly pronounced, such as urban heat islands, there exist significant differences in terms of vulnerability. For instance, members of low-income households are more likely to have underlying health conditions making them more vulnerable to heat stress, and they rarely have in place adaptation measures such as air conditioning. In practical terms, the results imply that with each recurring heatwave, there is an income gradient in heat-related mortality. On average, low-income households are more likely to face severe health effects and death than affluent households. These examples show that even in developed regions, deprived populations will face severe risks as climate-related disasters increase in frequency and severity.

Capacity to react and adapt to climate impacts depends on financial resources. Finally, the capacity to adapt to climate related disasters at the household level is strongly linked to savings or wealth. Since savings are less affected by disasters, households with higher financial wealth tend to incur lower consumption and well-being losses when hit by environmental disasters (Hallegatte, Vogt-Schilb, et al., 2017). Hence, financial inclusion can serve as a buffer against climate-related income losses. The losses that could be avoided through universal access to financial institutions are sizeable, exceeding US$1 billion per year in absolute terms for countries such as Peru or China. The financial inclusion and household wealth of the poorest and thus most exposed and vulnerable remain low, however, thus hindering effective adaptation. Figure

27 shows the net personal wealth share of the bottom 50% of the population by country in 2021. It appears that bottom 50% wealth shares are very low in all countries in the world, meaning that the poorest half of the population will struggle to adapt everywhere without public policy support. It also appears that the bottom 50% wealth shares are lowest in some of the countries where a strong adaptive capacity among the poor would yield the largest benefits in the face of aggravating climate change effects. Many countries in Southern Africa, for example, have some of the lowest bottom 50% wealth shares among all countries while being exposed to severe impacts in terms of droughts and extreme weather that threaten the livelihoods of large shares of the population.

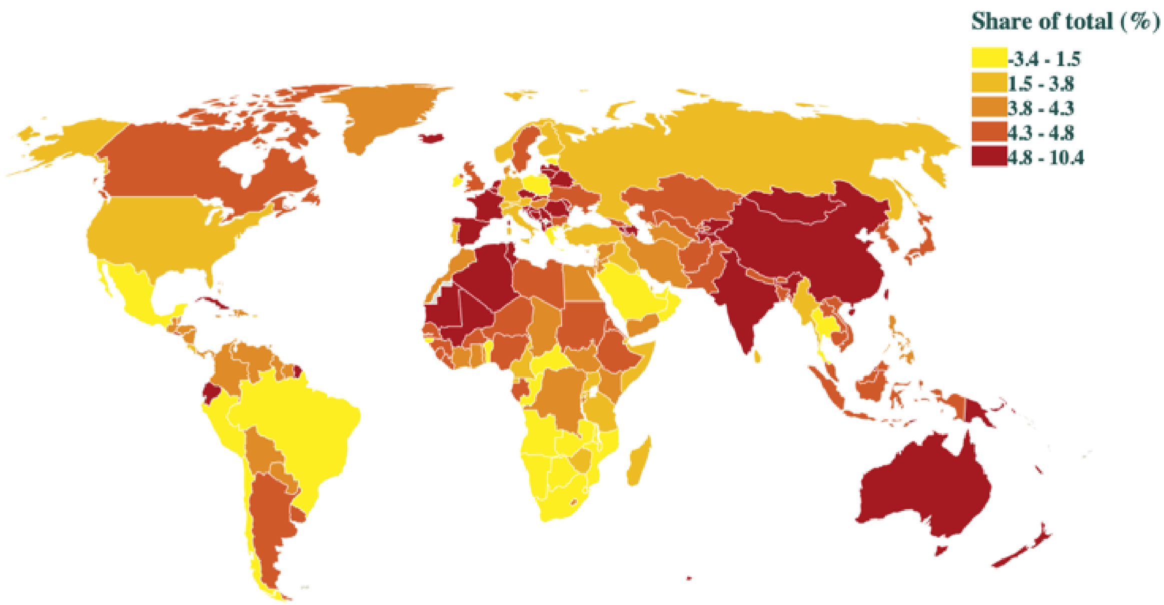

Figure 27: Net personal wealth share of the bottom 50% across the world, 2021

Notes: Net personal wealth shares of the bottom 50% are negligible across the world, and even more so in countries which are more likely to be affected by climate change. This has dramatic implications for the resilience and adaptive capacity of the poor in the most affected regions. **Sources:** Authors based on data from WID.world.

Successful programs show it is possible to reduce inequalities of exposure and vulnerability. Given that financial inclusion and personal wealth remain low in many areas that currently face the most severe climate hazards, social security and public transfers can play a key role in protecting the poor from the most adverse impacts. So-called social safety nets (SSN) have been recognized and adopted as a protective measure against income shocks in general and climate-related impacts in particular in recent years. Aimed at increasing the resilience to shocks of the most vulnerable, and providing immediate and well-targeted relief after disasters occur, safety net programs can take many forms, including cash transfers, public works programs, and public feeding programs (World Bank, 2018). For instance, Ethiopias *Productive Safety Net Program* (*PSNP*), provides cash transfers and public works to almost eight million people with the aim of reducing food insecurity and poverty. By establishing public works projects in infrastructure, community asset building, and environmental protection and conservation, the program represents an integrated poverty alleviation and climate adaptation effort (Woolf, Solomon, and Lehmann, 2018). However, it also illustrates the challenges associated with targeting such large-scale programs, as recent studies have found that the program has not significantly improved nutritional outcomes or dietary diversity for children despite a general increase in meal frequency (Bahru et al., 2020; Gebrehiwot and Castilla, 2019) Nonetheless, the World Bank estimates that globally, transfers from social safety nets have reduced extreme poverty (at US$1.90 per day) by 36% (World Bank, 2018).

Focus: Gendered Vulnerability

There exist strong gender differentials in the vulnerability to climate impacts. For instance, migration in response to climate-related disasters is highly gendered - women are often more severely affected by the shocks, and their labour burden often increases because they are less likely to migrate following exposure to disasters. Consequently, they often face a bigger burden of agricultural work or other low-paid and often risky activities in informal sectors on top of their existing domestic and community duties, which can lead to time poverty.

Reduced water security and poor sanitation often force women and girls to walk long distances to collect water, which reduces access to education for girls and can lead to increased exposure to other hazards. Lack of safe sanitation at home increases the risk of suffering sexual and gender-based violence (Schipper, Revi, et al., 2022).

In most low-income countries, land ownership is heavily male dominated. This reduces women's capacity to react to output losses from climate shocks as land ownership is linked to financial inclusion and credit access. Access to financial markets can in turn protect against temporary output losses and facilitate adaptive investment - a channel from which women are often excluded.

Furthermore, agency in climate negotiations and climate-development projects is heavily skewed and male dominated, which can make such projects gender blind and aggravate gendered vulnerabilities (Pearse, 2017).

The Indian National Rural Employment Guarantee Act, which provides a maximum of 100 days of public work per year at minimum wage has been recognized as an example of a successful safety net program. Fetzer (2020) shows that the program has served as significant protection against income losses from poor monsoon rainfall, by providing an alternative source of income for almost 50 million households in years preceded by comparatively low monsoon rains. In particular, the program insures poor rural households against agricultural income losses, thereby significantly weakening the link between reduced monsoon rainfall and violent conflict in India (see e.g. Vanden Eynde (2018)). The program is administered at the village level and chiefly involves public works in the areas of drought-proofing, micro-irrigation, sanitation, and road construction (Fetzer, 2020). By directing public works in specific areas, the program not only provides social security but also increases public good provision and climate resilience at the village level (Godfrey-Wood and Flower, 2018).

Social security and safety nets protect only a small fraction of the poor in low-income countries. At the same time, it is evident that safety nets can only be effective if coverage is sufficient and measures are efficiently targeted to the most disadvantaged but this is not the case in most low-income countries today. Figure 28 shows the coverage rate of the poorest quintile of the population for different types of social security and public transfers such as school meals and cash transfers. The average coverage of the poor in the low-income group of countries is consistently below 10% for all types of transfers. In comparison, more than half of the poorest quintile in the high-income group receive unconditional cash transfers. This highlights an additional gap in the capacity to adapt to and cope with climate hazards between the most deprived and the well-off, which also exacerbates the existing international adaptation gap.

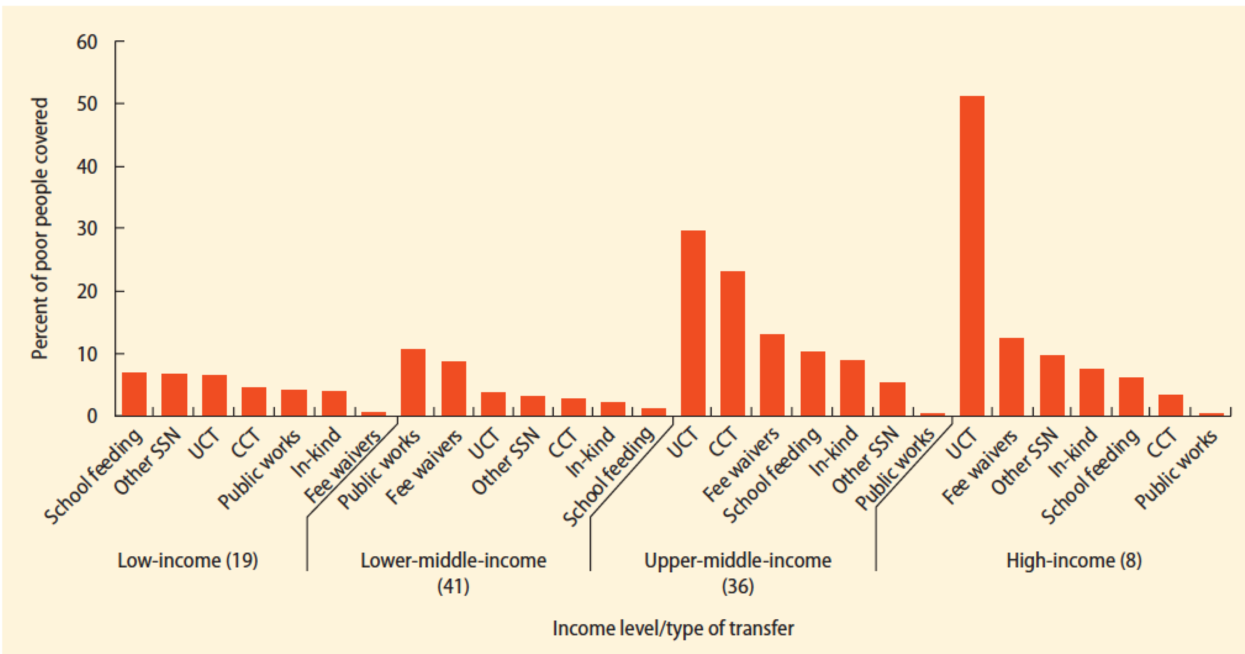

Figure 28: Coverage rates of the poor for different types of social security by country income group

Notes: Social safety nets and other social security measures are key to providing relief and to buffering the impacts of climate-related disasters. However, the poor in LMICs are insufficiently covered by these measures, which adds to the general picture of low resilience. CCT = conditional cash transfer; SSN = social safety net; UCT = unconditional cash transfer. **Sources:** Fig 5.3 from Hallegatte, Bangalore, et al. (2016)

Summary: inequality in climate losses and inequality in impacts

Before turning to the final section of this report, we now try to summarise some of the key findings from earlier sections. Our review of the recent literature revealed that there are large inequalities in greenhouse gas emissions between countries and within them. On top of these inequalities, research also highlights large inequalities in exposure and vulnerability to climate change impacts, between countries and within them. This inequality in impacts is due to the fact that low-income groups and countries tend to be more exposed to climate-related shocks, and are more vulnerable to them, because of a lack of socio-economic resources to face them and, in particular, a lack of capital. We should stress that these relationships between socio-economic groups and exposure to climate impacts are never perfect: all individuals face risks associated with climate change, wherever they live and independently of their socio-economic status.

Figure 29 summarizes the many facets of global carbon inequality from the point of view of the inequality of economic losses, of contributions to climate change and of economic resilience to climate events. More precisely, the graph shows the distribution of climate-change induced economic losses, along with the distribution of personal carbon footprints, and the distribution of personal wealth ownership across the world. The graph shows that the bottom 50% of the world population contributes to 12% of global emissions but is exposed to 75% of relative income losses due to climate change. Conversely, the top 10% of the world population, is responsible for close to half of all emissions, but faces just 3% of relative income losses. The graphs also highlights that the top 10% of the world population owns about three quarters of total personal wealth worldwide, while the poorest 50% owns just 2% of it. In other words, those who pollute less face more relative losses, but also have less resources to adapt. We provide methodological details on Figure 29 in the Appendix.

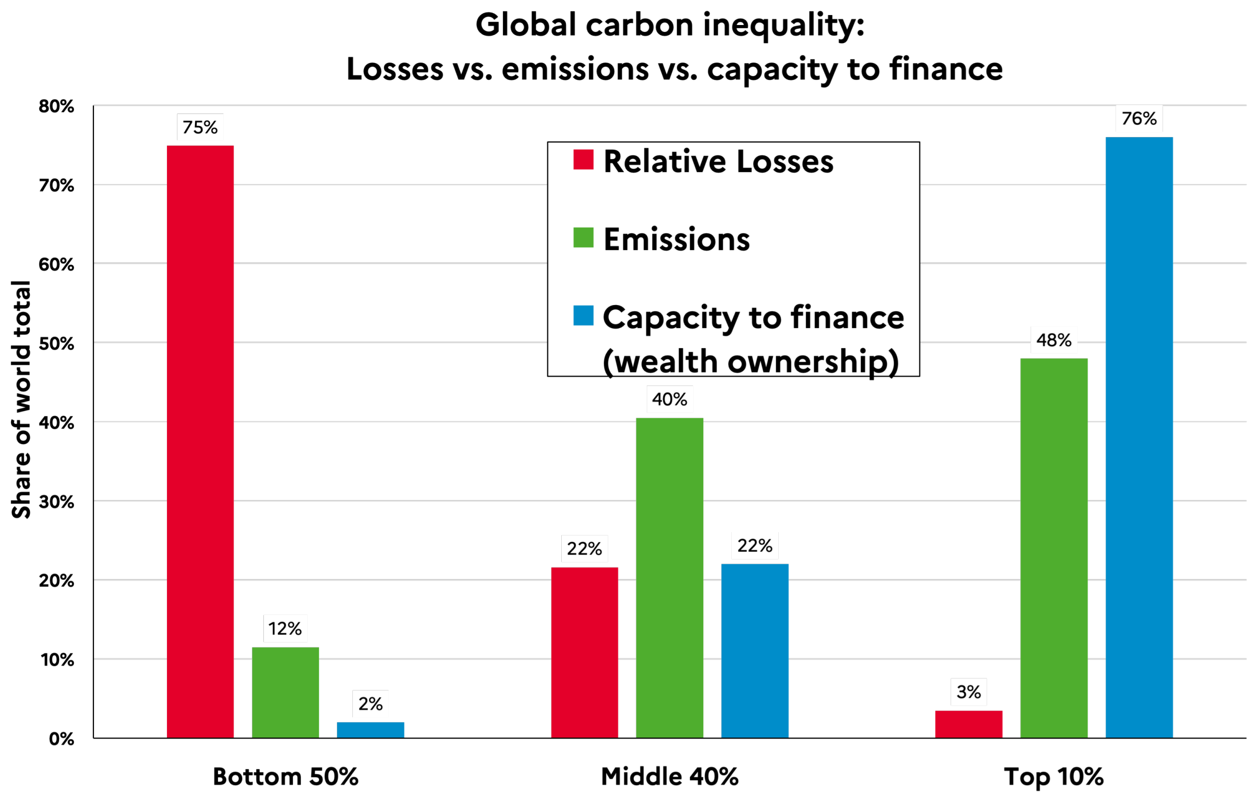

Figure 29: Global carbon inequality: losses vs. emissions vs. capacity to finance

Notes: The graph shows that the bottom 50% of the world population contributes to 12% of global emissions but is exposed to 75% of relative income losses due to climate change. Emissions inequality data based on the World Inequality Database for 2019. Losses can be measured in many different ways. In this simple representation, we use country-level GDP losses (in 2030 and relative to a world without climate change) from Burke, Hsiang, and Miguel, 2015. We attribute, to each emitter group within each country, a per capita percentage income loss score. We assume that the bottom 40% of the distribution is 20% more exposed to losses than the average population in a given country, a conservative estimate based on recent studies (see Hallegatte and Rozenberg, 2017 for eg.). The sum of these loss scores, weighted by population, gives a total global relative income loss burden, which is distributed across groups of emitters. These estimates of the global inequality in income losses should be interpreted with great care given the stylized approach taken to construct them. They nonetheless provide a useful representation of the large global inequality in climate change impacts found in the literature. **Sources**: Authors based on World Inequality Database and own calculations.

3. Tackling climate inequalities

The increase or persistence of climate inequalities is not inevitable. By targeting the key drivers of climate inequality and using tools already available to tackle them, governments, businesses, and civil society can reverse the observed trends.

We outline in this section possible ways to reduce climate inequalities. We view global warming as one of the greatest market failures in history and therefore mainly discuss the role of public policies below. Our main recommendations are the following:

- On the mitigation side, all governments need to reconsider their targets. Additional efforts are particularly but not exclusively required from the large historical emitters. Climate action remains the best recipe for tackling climate inequality. Accelerating mitigation programs may disproportionately increase economic stress on certain segments of the population within countries. In such cases, it will be crucial to offer generous support mechanisms to vulnerable actors (whether households or firms).
- Where climate finance provided and mobilized by developed countries falls short of the amounts pledged for developing countries and where adaptation remains vastly underfunded, several options could be explored to generate new government resources. Progressive wealth taxes on top-wealth holders could generate substantial resources, without asking more financial efforts from 99.9% of the population in rich and developing countries. Individual-based levies such as air passenger taxes and progressive wealth taxes, or taxes on specific, polluting economic sectors of the economy can also be mobilized. The removal of fossil fuel subsidies can also save significant amounts of funding, but careful design and timing are critical.
- Whatever the options chosen, the bottom line is that the climate finance agenda is intrinsically linked to national tax capacity building and the advent of an "ecological welfare state", capable of ensuring a just transition towards the objective of the Paris Agreement over the entire course of the 21st century. Against this long-term and quite ambitious view, we attempt to provide policymakers with a grid or matrix to figure out the intended and unintended distributionial effects of their

climate policies.

3.1. Taking stock of mitigation & financial efforts to curb climate inequalities

The reduction of climate inequalities between countries is essential to the United Nations Framework Convention on Climate Change (UNFCCC, or Convention) and the history of climate negotiations. In 1992, the UNFCCC gave legal form to principle of equity, inter alia through the common but differentiated responsibility and respective capabilities (CBDR-RC) principle (Art 3). In the run-up to the Paris Agreement, developing countries defended the distinction between developed and developing countries, which was retained in the main, although weakened in some areas.

Article 2.1 of the Paris Agreement enhances implementation of the Convention, strengthening the global response to the threat of climate change in the context of sustainable development and efforts to eradicate poverty. Parties agreed that this would include:

"(*a*) *Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change*;

(*b*) *Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production*; and

(*c*) *Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development."*

Article 3 draws the list of areas where *"ambitious efforts"* (enshrined in the nationally determined contributions) should be undertaken and communicated while recognizing the need to support developing country Parties for its effective implementation. These policy and cooperation areas are mitigation, adaptation, finance, technology development and transfer, capacity building, and a transparency framework for action and support. Although the Paris Agreement scrupulously avoids any reference to the idea of burden sharing, it does state that developed countries should take the lead in mitigation and finance.

Article 4 on mitigation recognizes that developed country Parties *"should continue taking the lead"*[9] and that peaking of greenhouse gases will take longer for developing countries, implicitly acknowl-

[9] "shall" was replaced at the last minute by "should"

edging the principle of common but differentiated responsibilities (CBDR).

Article 9 on climate finance asserts that *"developed country Parties should continue to take the lead in mobilizing climate finance from a wide variety of sources, instruments and channels, noting the significant role of public funds, through a variety of actions, including supporting country-driven strategies"*. The landmark figure of US$ 100 billion per year as a floor was not included in the Agreement because of fierce opposition from key developed countries. Instead, paragraph 53 of the accompanying COP21 decision states that:

"(. . .) *developed countries intend to continue their existing collective mobilization goal through 2025 in the context of meaningful mitigation actions and transparency on implementation; prior to 2025 the Conference of the Parties* (...) *shall set a new collective quantified goal from a floor of US$100 billion per year, taking into account the needs and priorities of developing countries."*

Interestingly, high-income countries sought to integrate climate considerations into international development assistance (ODA), yet this was strongly resisted by developing countries, who feared that climate support would substitute for development assistance instead of being added to it, and the Agreement eventually included no mention of ODA.

The policy levers likely to curb climate inequalities beetween countries are also to be found in various initiatives triggered by the regular occurrence of the Conference of the parties (COP). This is the case of the US$100 billion pledge, which dates back to the 15th Conference of the Parties (COP15) of the UNFCCC in Copenhagen in 2009. Renewed commitments were made at COP26 in Glasgow in 2021, including a promise by developed country Parties to double their adaptation finance by 2025 to US$40 billion per year compared to 2019. In the same vein, some public development banks and development finance institutions have started to align their portfolio with the objectives of the Paris Agreement.

All governments should reconsider their mitigation targets, and chief among these, historical emitters.

The "ratchet mechanism" of the Paris Agreement, committing Parties to increase efforts over time, seems to function quite well, yet without delivering the magnitude of the expected emission cuts by any deadline so far. Countries all over the world have submitted nationally-determined contribution (NDCs). As of 12 October 2021, 166 Parties had submitted their new or updated NDCs. Yet these contributions only marginally address the emissions gap. According to estimates from the World Resource Institute (Franzen, 2021), the current round of updated NDCs is on track to shave off about 10% of the emissions gap - adding to the 10% prior reduction that the first round of NDCs has led to. The remaining gap by 2030 to be on track with the 2°C scenario is about 12 Gt CO2e, which is twice as big as the effect of initial, new and updated NDCs. The remaining gap in the 1.5°C scenario (which is fairer) is 4 Gt CO2e further away. The new and updated targets at COP26 would at most, limit global warming to 2.4°C, almost a full degree above the Paris temperature limit according to estimates by the Climate Action Tracker. Glasgow sectoral initiatives would close the 2030 emissions gap by a further 9%. Yet even with all new Glasgow pledges for 2030, global GHG emissions will be roughly twice as much in 2030 as required for a 1.5°C increase.

As a direct consequence, all governments need to reconsider their targets. This is particularly the case for large historical emitters, the list of which will include large emerging economies, as emissions continue to rise and to delay the emissions peak date because their mitigation efforts are too little or late. It is worth noting that although comparing efforts made by one NDC to another across countries is impossible because countries' initial NDCs were not all equally ambitious, it remains true that the countries pledging the deepest 2030 emissions reductions relative to their previous NDCs are mostly to be found among LICs and MICs, with Mauritania, Burundi, and Togo in the lead.

Climate finance falls short of mobilizing the amounts pledged for developing countries.

It is estimated that high-income countries mobilised US$83.3 billion for climate action in developing countries by 2020 (OECD, 2022). This means that the aggregate level of such financing remained US$16.7 billion short of the flagship US$100 billion goal (Figure 31). Most of the money came from public grants and loans, transferred either bilaterally, from one country to another directly, or from multilateral development banks (MDBs). A smaller amount - between 17% and 24% depending on the year - was private finance that the public money is said to have mobilized, such as loan guarantees and loans granted alongside public funds (Timperley, 2021).

Although adaptation finance rose by US$8.3 billion between 2019 and 2020, mitigation represented most (58%) of the total funding provided in 2020 (Figure 31). Middle-income countries captured the lion's share of the finance mobilized by

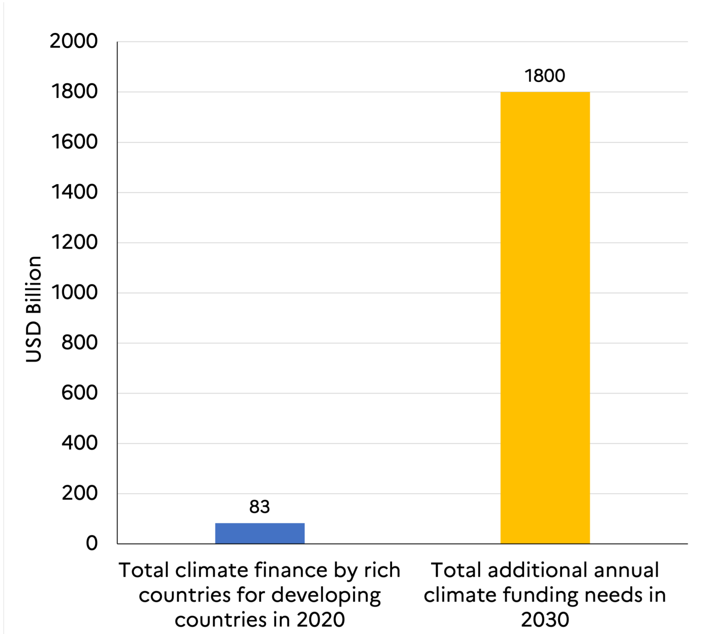

Figure 30: Total additional climate funding needs for developing countries by 2030

Notes: The figure shows the total volume of climate finance provided and mobilized by rich countries in 2020 vs. additional climate funding needs by 2030 on mitigation adaptation and losses. **Sources**: Authors based on OECD, 2022 and Songwe, Stern, and Bhattacharya, 2022.

OECD countries, at 70%, dwarfing low-income countries, which received just 8% of the estimated climate finance flows.

Between 2016 and 2020, the 40 Small Island Developing States (SIDS), the 46 Least Developed Countries (LDCs), and 57 fragile states respectively represented 2%, 17% and 22% of total climate finance, with huge per capita discrepancies among them. The annual per capita median was US$81 for SIDS; US$14 for LDCs, and US$11 for fragile states. Provided largely through loans (71%) and to a lesser extent through grants (26%), climate finance faces absorption capacity problems and debt sustainability thresholds in poor and fragile countries. Official development aid (ODA), including grants and concessional loans, might be better suited to such countries, yet the evolution of ODA in relation to climate objectives shows a similar pattern to climate finance. According to the OECD Development Assistance Committee (DAC), the trend in bilateral climate-related ODA has been quite flat both in proportion to total ODA and in absolute terms since the signing of the Paris Agreement. The OECD estimates that only one third of such aid has adaptation or mitigation as its principal (primary) objective. Two thirds of the aid include them as significant (secondary) objectives, i.e. adaptation or mitigation considerations are included in broader projects with multiple development ob-

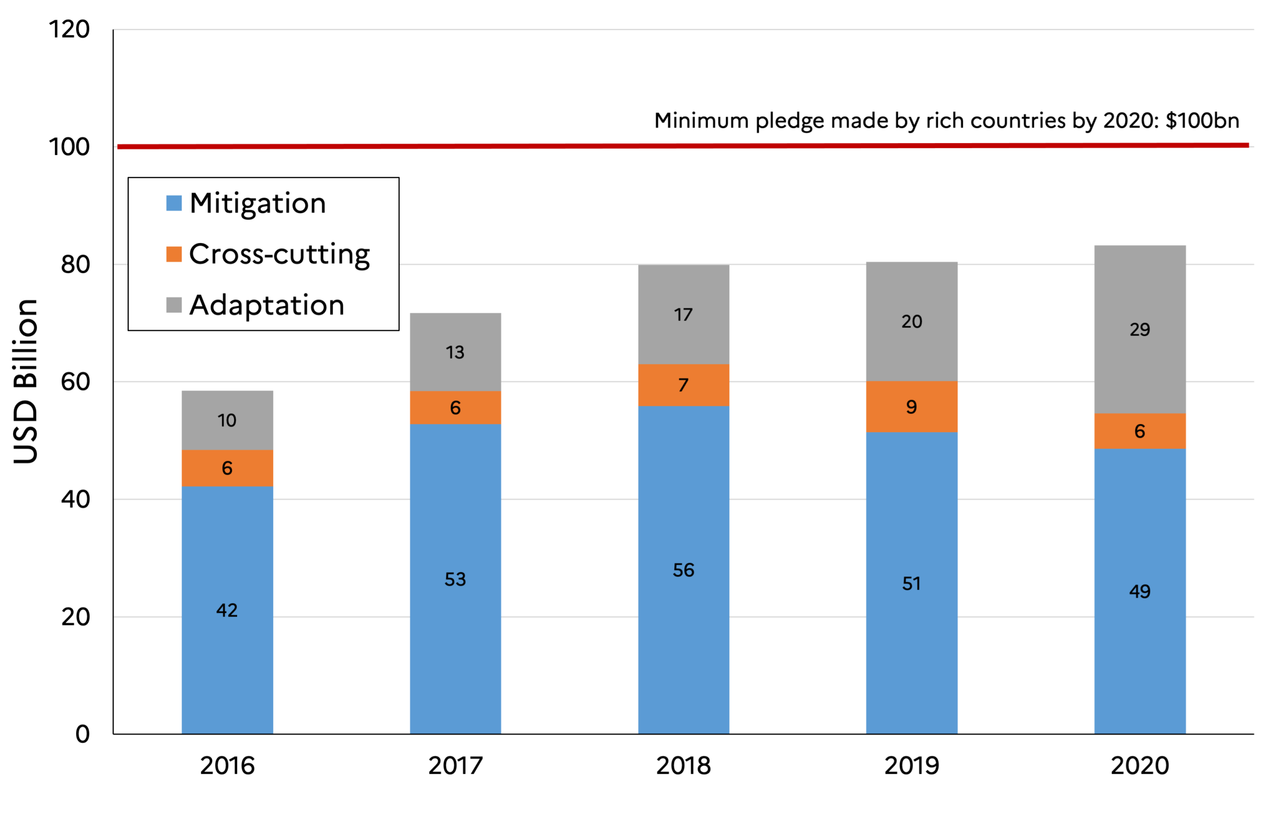

Figure 31: Climate finance mobilized by developed countries for developing countries in 2016-2020 (USD Billion)

Notes: The figure shows the total volume of climate finance provided and mobilized by developed countries for developing countries between 2016 and 2020 and the split between mitigation, adaptation and cross-cutting activities. In 2020, USD 29 billion were mobilised for adaptation. **Sources**: Authors based on OECD (2022).

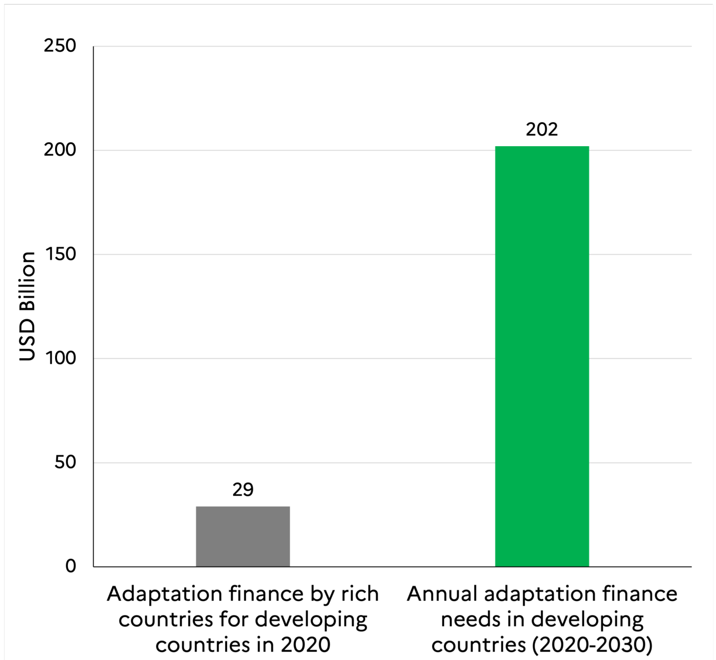

Figure 32: Adaptation funding needs in developing countries vs. adaptation finance

Notes: The figure shows the total volume of adaptation finance provided and mobilized by rich countries in 2020 vs. total adaptation finance needs by 2030 according to UNEP. **Sources**: Authors based on OECD, 2022 and UNEP, 2022.

jectives. Moreover, the share of climate-related ODA called "significant" has been growing only moderately since 2015. Climate change adaptation ODA is more often marked "significant" than mitigation-related ODA, which is consistent with the weight of adaptation financing needs in poor and vulnerable countries.

Adaptation remains vastly underfunded

The costs of adapting to climate change in developing countries are indeed substantial and rich countries have committed to scale up support for adaptation in developing countries, particularly in LDCs and SIDS. Promises were made to double adaptation finance between 2014 and 2020 under a road-map presented to COP 22 in 2016 - and reiterated between 2019 and 2025 following COP 26.

The most important sources of approved funding for adaptation projects are currently the Green Climate Fund (GCF), the Least Developed Countries Fund (LDCF) administered by the Global Environmental Facility (GEF), the Pilot Program for Climate Resilience (PPCR) of the World Bank Climate Investment Funds (CIFs) and the Adaptation Fund (AF). Data from Climate Funds Update (CFU) however shows that developed countries contributions to these funds remain low compared with their contributions to mitigation funds. Adaptation remains underfunded. This is true when it comes to pledges but even more striking in relation to actual disbursements. The transformation ratio of pledges into deposits and approvals is low: overall, just 21% of pledged funds are actually approved (see Figure 33).

The GCF, which is set to devote 50% of its fund-raising to adaptation, with half of that going to the SIDS, LDCs and African states, is the largest provider of such finance on paper, but the ratio of approved spending to pledges is the lowest among the major climate funds between 2003 and 2020. This low ratio partly reflects the increasing volume of pledges made for the first replenishment (2020-2023) while spending approvals are still pending.

The cumulative finance approved for adaptation from key climate funds tracked by the CFU grew to US$5.8 billion in 2020. This figure is much lower than OECD climate adaptation finance estimates (Figure 31), but it reflects actual disbursements more accurately. It refers to approvals rather than deposits, and according to the explicit mandate given to the climate funds considered, accounts mainly for spending on targeted adaptation objectives. The total amount is almost negligible compared with what will be required by 2030 (Figure 32), which amounts to US$140 to 300 billion for developing countries alone (UNEP, 2021), but does not take into account the estimated costs of loss and damage, which by 2030 in developing countries will add another US$290 billion to 580 billion to the bill (Markandya and González-Eguino, 2019).

Adaptation is underfunded, increasing the amount of humanitarian funding required for climate disaster relief what is referred to as "Loss and Damage" in UNFCCC terminology, and "losses and damages" in IPCC reports. Carty and Walsh (2022) estimates that the money needed for UN humanitarian appeals at times of extreme weather events are eight times higher today than they were 20 years ago, and that since 2017, about half (54%) of all UN appeals for climate disaster relief after droughts and floods have gone unanswered. For every US$2 a country asks for to deal with extreme weather problems, they receive only around $1 a shortfall of up to US$33 billion (id.).

Funding requirements beyond adaptation

The Climate Policy Initiative finds that global climate finance needs (for all countries including investment and spending for mitigation, adaptation, loss and damage) will amount to $6300 billion worldwide in 2030 (Naran et al., 2022), and should be about $4200bn in 2021.

	Pledged	Deposited (USD million)	Approved	Approved / Pledged (%)
Green Climate Fund	20 320	10 179	1 620	8%
Least Developed Countries Fund	1 686	1 584	1 266	75%
Pilot Progam for Climate Resilience	1 145	1 145	987	86%
Adaptation Fund	1 039	978	777	75%
Global Climate Change Alliance	1 333	1 333	381	29%
Adaptation for Smallholder Agriculture Program	407	332	293	72%
Special Climate Change Fund	380	373	284	75%
Global Environment Facility Trust Fund	701	700	132	19%
Total	**27 010**	**16 624**	**5 740**	**21%**

Figure 33: Multilateral funds supporting adaptation: pledged vs. approved

Notes: The figure shows the size (in USD millions) of funds supporting adaptation, as well as the ratio between pledged and approved projects, which remains very low (21% overall). **Sources**: Authors based on Watson, Schalatek, and Evéquoz (2022).

In 2021, total climate finance actually amounted to $850bn – giving a sense of the magnitude of the overall challenge. Songwe, Stern, and Bhattacharya, 2022 find that total climate finance in low and middle income countries (excluding China) amount to $2000-2800 billion per year in 2030. A part of the total investment and spending needs in developing countries is already covered by existing and planned investments, such that the remaining *additional* investments needs would be about $1800 billion per year in 2030 for low and middle income countries excluding China (Figure 30). Out of this total, adaptation is found to represent just about a tenth of the total. Loss and damage represent another 15% of needs, and the rest is related to mitigation. [10] Put differently, total incremental climate finance needs in developing countries could be around ten times higher than the volumes required for adaptation only.

[10] See Table 3.1 and Figure 3.1 from Songwe, Stern, and Bhattacharya (2022). We estimate the share of incremental adaptation needs out of total incremental climate finance needs, based on the share of adaptation in total investment requirements.

Focus: Towards A Loss and Damage Fund

SIDS and LDCs have been calling for innovative measures to mobilize climate finance for over three decades. Vanuatu and the Alliance of Small Island States first proposed financing for climate change-induced losses and damages in 1991. Despite numerous SIDS and LDC proposals, discussions among states, industry and academics, and the establishment of the Warsaw International Mechanism for Loss and Damage Associated with Climate Change Impacts (in 2013 at COP 19), actual funds for climate losses and damages have yet to materialize. Despite 30 years of discussions, funds transfers from wealthy states to less wealthy ones for loss and damages have been minuscule.

The 6th Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) by the Working Group II (Impacts, Adaptation and Vulnerability) presents an alarming assessment of climate change risks, drawing attention to irreversible and permanent effects now and expected in the foreseeable and long-term future. Most notably, the assessment brings together scientific work on adaptation limits and the residual risks that result in losses and damages. The concept is defined as "...adverse observed impacts and/ or projected risks and can be economic and/or non-economic" (IPCC, 2022), and is deliberately distinguished from the term Loss and Damage (L&D) used in Article 8 of the Paris Agreement and UNFCCC negotiations. Both terms refer to the irreversible impacts caused by anthropogenic climate change in the light of the considerable advances in attribution science since the IPCC AR5 (Otto, James, and Myles, 2019). Particularly alarming in the AR6 are projections showing that severe climate risks, including irreversible impacts, are expected even in scenarios of ambitious emissions reductions (in line with the 1.5°C - 2°C target), while the latest climate update by the World Meteorological Organization shows that the 1.5°C limit may be imminent.

COP26 in Glasgow delivered a mixed bag of successes and shortcomings; in particular, the outcomes of Loss and Damage finance were widely seen by climate-vulnerable developing countries as unsatisfactory (Bauer, 2021, Vallejo, 2021). The European Union (EU) amongst others, faced strong criticism from G77 countries for opposing the proposal to establish a finance facility for Loss and Damage under the UNFCCC. COP26 closed with the Glasgow Climate Pact and the launch of the two-year Glasgow Dialogue to look at funding arrangements for activities that can avert, minimise, and address Loss and Damage. Vulnerable developing countries emphasise major gaps in the latter, associated with occurring and projected residual risks, as distinguished from efforts in mitigation and adaptation. (Boyd and Keene, 2021, Anisimov et al., 2022.) In a spectacular diplomatic move, the EU was the first major block to concede on developing countries demands for the creation of a loss and damage fund, one of the key outcomes of Sharm el-Sheikh COP 27. Though the timeline for operationalisation of the fund is quite short (COP28), politically sensitive questions remain on who benefits and who pays. The target beneficiaries of the Loss and Damage Fund are developing countries that are particularly vulnerable to the adverse effects of climate change but this deliberate vague formulation is too broad to tell who is in who is out. Who pays to such a fund is an even more contentious question: the European block and the United States are clearly the largest historical emitters, but the US has a poor track record of delivering on climate finance. Other high-income and upper-middle income countries with high emissions like China, Russia and Saudi Arabia are wary of any expectation that they might be called upon to foot some of the bill.

Though it is uncertain whether such a fund could mobilise funding to the scale and pace required, its creation lends by itself a new-found legitimacy to the old idea of an international levy on maritime, aviation or fossil fuels to finance adaptation to climate change. This was publicly envisaged by the vice-president of the Euorpean Commission, Frans Timmermans, in Sharm-el-Sheikh, as it sidesteps the question of which country pays, to focus on carbon-intensive products (Vallejo, 2022). Other options could include revenues from a carbon border adjustment, a measure currently being discussed in the European Union. This option could make a lot of sense as the tax would, in part, be a tax on pollution activities in developing countries. At this stage, however, it is likely that these new revenues will be used to increase the EU's "own" (i.e. federal) resources. In other words, the question of how to finance the climate funding gap remains mostly unanswered.

3.2. Progressive taxes to fill the climate funding gap

According to Carty and Walsh (2022), estimated loss and damage costs could increase to between US$290 billion and US$580 billion a year by 2030, and reach the trillions by 2050. Much of this will be shouldered by developing countries themselves, those most vulnerable to the effects of climate change.

Last but not least, current adaptation finance pledges might be overestimated, if we take into account the rebranding of existing development programs as adaptation projects. As Schipper, Eriksen, et al. (2021) note, adaptation finance (as defined and measured by OECD) often ends up funding existing development activities that tick the adaptation box simply because they address climate-sensitive sectors or livelihoods. If this "retrofitting" of adaptation into development assistance (Eriksen et al., 2021) were true then estimates of current adaptation finance flows, already small, would be even smaller.

The adaptation/loss and damage funding gap could be bridged in many ways through existing funding channels, or with the creation of ad hoc facilities (El-Said, 2022). It was clear after the COP13 in Bali and the COP15 in Copenhagen that adaptation financing needs would rise along with the then-projected temperature increase. Estimates have been refined on the predictable adaptation funding gap and ideas have emerged about possible sources of additional funding.

A levy on aviation and shipping

A levy on aviation and shipping has been proposed on several occasions at the UNFCCC and other international fora as a way to fund climate change actions in developing countries. In 2008, the Maldives, on behalf of the LDCs, submitted a proposal to establish an International Air Passenger Adaptation Levy (IAPAL) based on the model of the French "Leading Group" solidarity levy to combat HIV/AIDS, and researchers fine-tuned the idea (Van Beukering, Brouwer, and Brander, 2007, Chambwera and Müller, 2008, Hepburn and Müller, 2010). The UN Economic Commission for Africa took up the idea of an air travel adaptation levy in 2011 (Nations, 2011).

Although it explicitly aims to limit global warming to well below 2°C, and preferably to 1.5°C compared with pre-industrial temperatures (which means keeping adaptation costs to their lowest reasonable minimum), the Paris Agreement did not allay fears among poor and vulnerable countries of a temperature increase beyond 2°C. Neither did it silence the call for more adaptation funding, inter alia through earmarked resources levied on individual activities such as air travel and maritime shipping levies (Chancel and Piketty, 2015, Boyd and Keene, 2021). In its simplest form, the air travel levy is an international impost earmarked for helping the most vulnerable to cope with the damaging impacts of the activity being levied. It is imposed not on states but on individuals. Its prime objective is to raise funds for adaptation projects, which means that it is not aimed at affecting behaviour or reducing the size of the levy-base over time by discouraging international air travel, particularly long-haul flights. It can be implemented either as a (progressive) percentage tax on the ticket price, or as a (differentiated) poll levy. The original IAPAL was based on the latter simply because it is easier to monitor and collect.

Ahead of the COP26 in Glasgow, the call to make polluters pay for climate loss, damages, and adaptation grew louder. The UN Special Rapporteur on Human Rights and the Environment relayed this call, pointing at the individual responsibility of "wealthy individuals" - something that could not have been written about five years earlier because of a lack of data and a conservative approach to climate responsibilities that focused exclusively on the nation-state.

The Special Rapporteur's briefing gives a sense of how much could be collected for Loss and Damage and adaptation without impairing the air and maritime transport businesses. The proposed shipping levy is based on the 2021 proposal by the Marshall Islands and Solomon Islands to the Marine Environment Protection Committee of the IMO.[11] The proposed air passenger levy is similar to the above-mentioned 2008 international air passenger adaptation levy advanced by the Maldives (IAPAL).[12]

Two scenarios are considered. In the first *best-case scenario* all countries participate and apply both levies, and the frequency of air passenger travel returns to 2019 levels (4.486 billion commercial air passengers per year, rounded down to 4 billion). In the second *worst-case scenario* only half of the countries introduce the levy policies, and commercial air travel continues at 2020 levels (approximately 1.787 billion passengers,

[11] Republic of the Marshall Islands and the Solomon Islands, Reduction of GHG Emissions from Ships: Proposal for IMO to Establish a Universal Mandatory Greenhouse Gas Levy, March 10, 2021, MEPC76/7/xxl; and Anastassios Adamopoulos, Lloyds List, "Marshall Islands Demands $100 Tax on Shipping Emissions", March 11, 2021.

[12] Republic of the Maldives, International Air Passenger Adaptation Levy: A Proposal by The Maldives on Behalf of the Group of Least Developed Countries (LDCs) within the Framework of the Bali Action Plan, December 12, 2008.

rounded up to 2 billion passengers), when the COVID-19 pandemic reduced the frequency of commercial air travel by approximately 60 percent. In both scenarios, calculations assume that the maritime shipping CO2e emissions rate remains at 2018 levels (919 million tons of CO2 per year), as reported by the IMO.

If all 195 state signatories to the Paris Agreement imposed both levies and air passenger travel returns to pre-pandemic levels, then the levies proposed by the Special Rapporteur would generate between US$132 and US$392 billion annually to support SIDS and LDC responses to climate change-induced losses, damages, and adaptation, with the possibility of some funds being allocated to research, development, and deployment of sustainable fuel and emissions-free technologies.

If only half of the targeted countries participate and commercial air travel remains at the low 2020 levels, then the levies would generate between US$56 and US$121 billion of revenue each year, an amount of funding still deemed *"significant to address climate damages and vulnerabilities that are already substantial andare rapidly increasing"* (id.).

Beyond air passenger levies, there have been calls over the past few years for progressive wealth taxes to tackle climate change (Carty and Walsh, 2022). However, few concrete proposals have been made for the allocation of such funds to developing countries adaptation needs. In the US, in the context of the Inflation Reduction Act of 2022, the Biden administration passed a new tax on large corporations to finance its national climate investment policies. One of the justifications for this new tax, according to the government, was the need to finance US mitigation and adaptation efforts. The link with adaptation finance for the developing world was absent from the discussion. This case illustrates the state of the debate in other rich countries relatively well: progressive income and wealth taxes are increasingly advocated by civil society and certain governments, sometimes to finance local climate efforts, but very seldom are they invoked as a way to contribute to bridging the climate funding gap for the countries most in need.

Raising macroeconomic tax rates in low- and middle- income countries to combat climate change

This report has highlighted some of the reasons why rich countries should play a bigger role in funding adaptation measures in LMICS in the coming years. The global adaptation funding landmark objective of US$100 billion per year was supposed to be a floor, not a ceiling, and to date not even that has been met.

More generally, let us also note that overall development assistance, which currently accounts for around 0.2% of global GDP, remains particularly limited compared with actual requirements in the Global South. High-income countries must do more to close this gap and to increase aid transfers. However, the overall adaptation funding gap and development finance needs will not only be met by more finance from high-income countries; climate action financing will also require domestic resource mobilization, i.e. increases in national tax capacities for adaptation and development purposes.

Figure 34 shows tax revenues as a share of gross national income (GNI, a measure close to GDP) in Sub-Saharan African and South and South-East Asian countries compared to Europe. The overall macroeconomic tax rate in these countries is on average just over 15%. Spending on healthcare is around 2-3% of national income, and similar for education. This graph illustrates the necessity to increase tax revenues and social spending overall in low- and middle-income countries, particularly in Sub-Saharan Africa and South and South-East Asia. In comparison, rich countries have a macroeconomic tax rate of 30-50% of their national income and yet, in many cases, they struggle to finance solutions to new problems such as ageing populations and adaptation to climate change. In other words, the 30-50% macroeconomic tax rate observed in high-income countries should be seen not as an absolute maximum target for LMICs but rather as a threshold to be reached in order to fund well-functioning societies.

How to increase tax capacity in low and middle-income countries? There is no easy answer to this question and it is a welcome development that the issue has recently been put on the agenda of several donor countries and, more importantly, of LMIC governments themselves. For donors and development agencies, a key lesson learnt, as cited earlier in this report, is that programs that strengthen domestic resource mobilization in LMICs should not be treated separately from adaptation funding programs: one dollar of aid in tax capacity building may be just as important for adaptation as one dollar of aid invested directly in the development of climate resilient infrastructure.

Increasing macroeconomic tax revenues via more progressive taxes

Focusing on ways to increase macroeconomic tax rates in order to finance public investments and spending, it is useful to recall that the rise of taxation in high-income countries occurred in tight connection with highly progressive tax schedules in the mid 20th century and high GDP growth (Piketty, 2017). There is no mystery

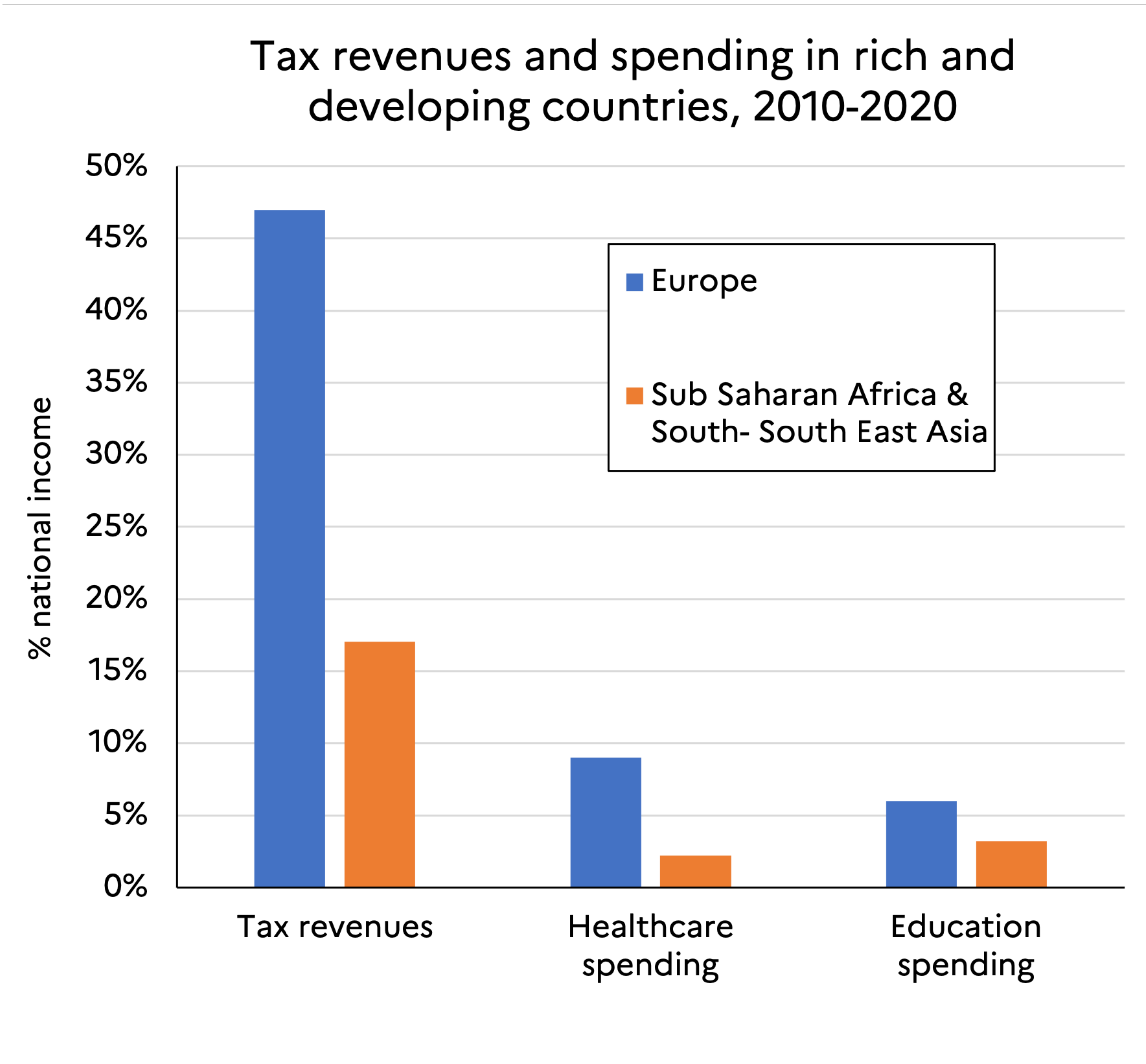

Figure 34: Tax revenues and spending in Europe vs. Sub-Saharan Africa and South and South-East Asia, 2010-2020

Notes: The figure shows that overall tax revenues remain very low in low-income countries, as compared to European countries (47% vs. 17%). European countries spend 6-9% on education and healthcare vs. 2-3% in Sub Saharan Africa and South and South East Asia. European countries are represented by the average of France, Germany, the UK and Sweden. **Sources**: Authors, based World Inequality Report 2022, chapter 10 here: to reduce the burden on low- and middle-income groups, high-income and high-wealth economic actors are asked to contribute a significant share of the new taxes. There is an economic as much as a political argument at stake: economically, there are many very good reasons to limit extreme inequality and taxes are useful instruments for doing just that (Diamond and Saez, 2011). Politically, leaders of high-income countries have also found it is easier to increase overall tax revenue by demanding greater contributions from those at the top of the distribution (Zucman and Saez, 2019). In 2022, tax progressivity is very low in LMICs, where taxes are indirect and are often largely imposed on consumption (Chancel, Piketty, et al., 2022; Martorano, 2018).

Taxes on large wealth holders and large inheritances, and progressive income tax rates are typically missing from the tax equation in LMICs. Let us note here that improving tax and statistical administrations typically go hand in hand: without good data, it is impossible to tax in a fair way, and without progressive taxation, it is hard to obtain good data on who owns what (Chancel, Piketty, et al., 2022). To be clear, developing fair and modern tax systems is no easy undertaking. But the reality is that programs seeking to improve tax and statistical apparatuses remain limited in both scope and funding. The Addis Tax Initiative, launched in 2015 as a multi-stakeholder partnership to support domestic revenue mobilization, was a welcome development. However, the 2019 review of this initiative suggested that the momentum created at its launch was not sustained and ambitions for the program remain limited **(see Focus on Addis Tax Initiative)**.

Focus: Mobilising domestic revenues through the Addis Tax Initiative

The Addis Tax Initiative (ATI) was initiated in 2015 during the Third International Conference on Financing for Development in Addis Ababa to support the implementation of the Addis Ababa Action Agenda on Financing for Development. Since then, more than 60 developing countries, providers of development co-operation and supporting organisations have joined the ATI. Among other objectives, the ATI aimed to double existing support for technical cooperation in taxation by 2020. The objective is quite modest given that the ATI started with a very low base. About US$200 million, or 11% of ODA, was earmarked for domestic revenue mobilisation (DRM) projects in 2015 according to the OECD[a].

Until 2015, there was no standard OECD Development Assistance Committee (DAC) code against which to report tax projects[b]. DAC data shows that the ATI target was reached by 2018. The aggregate figures remain low, however, compared with the funding required to drive and monitor the transition towards the sustainable development goals. On average, 0.2% of all ODA was targeted to DRM projects between 2015 and 2020, totalling about US$400 million per year. The ratio is slightly higher for Sub-Saharan African countries, which were recipients of between 25% and 60% of ODA for domestic revenue raising purposes over the same period. There are positive lessons to draw from ATI. Setting goals, even modest ones, triggers measurement efforts, and spurs co-operation and action. The launch of the ATI was a key driver in forming the DRM-specific code in the OECD CRS. This in turn has helped to increase the amount of ODA for DRM, which was previously based solely on word-search methods[c].

[a] OECD Creditor Reporting System (code 15114) See this hyperlink (click)

[b] The list of OECD DAC Creditor Reporting System (CRS) code includes "Domestic revenue mobilisation" (code 15114), which is the sum of three categories: Tax collection (15116), Tax policy and administration support (15155) and Other non-tax revenue mobilisation (15156). The OECD CRS database provides data for DRM (15114), without details of its subparts.

[c] Development Initiative (2018). ODA for domestic revenue mobilisation: progress, prospects and opportunities for effective support. Discussion paper at this hyperlink (click).

Early estimates show that ATI signatory countries have increased their DRM-ODA (donor countries) and tax-to-GDP ratio (recipient countries) relatively more than countries who have not joined the initiative[a]. In the wake of the ATI, key donors (Australia, France, Japan, Luxembourg, Norway, Switzerland, United Kingdom) consolidated their partnership under the Global Tax Program with US$80 million secured to date within a dedicated facility hosted by the World Bank[b]. There is little doubt that an initiative such as the ATI, created within the SDG framework, has given a much higher profile to tax collection than it would have had otherwise, setting a new agenda for cooperation and development agencies. Connecting the ATI with global tax initiatives and domestic climate inequality reduction policies would be a logical next step. Global taxes help to reduce inequalities and to generate global public revenues which, once channelled to DRM support activities in developing countries, lead to further reductions in climate inequality. As a starting point, the need to tackle economic inequalities through the tax system with, inter alia, a progressive income tax, a greater focus on wealth taxation, and sector-specific taxes addressing climate change, is now widely accepted in the donor community[c]. On their side, signatories to the ATI have issued a new 2025 Declaration[d], adding a qualitative dimension to both revenue collection in developing countries and the provision of DRM support by donors. Beyond revenue generation, the new declaration emphasises the need to reduce inequalities and to protect the environment, while involving stakeholders (e.g. civil society organisations) to enhance government accountability in revenue collection and spending. The political traction of a sustainable development agenda headed by the goal of reducing inequality seems thus quite clear, leaving ample room to scale up efforts and to test new ideas to reverse the rising trend in climate inequalities.

[a] See this link
[b] See this link
[c] See for instance IBRD/IDA Board Briefing on DRM, June 2021 at this link
[d] See this link

Increasing LMIC's taxing rights on multinationals' profits

While the strengthening of tax capacities in LMICs ultimately depends on these countries, there is much that the international community can do to foster the process. First, it is important for donor agencies to better map the economic imbalances associated with international aid and climate finance flows. In most countries that receive development or adaptation aid, money outflows in the form of multinational profits from high-income countries are often superior to public or NGO aid. Indeed, capital income flowing from African countries to the rest of the world represents on average three times the amount of international aid that went into them between 1970 and 2012, and the situation does not seem to have significantly changed since then. In addition to licit capital outflows, multinational companies also organize illicit flows out of low-income countries. Africa loses nearly US$89 billion a year in illicit financial flows, equivalent to more than 3.5% of the continent's GDP, which is also more than it receives in development aid. Put differently, while certain high-income countries provide generous aid support programs to LMICs, these transfers can be nullified by the actions of multinationals based in those same high-income countries.[13]

Given this situation, high-income countries serious about their calls for the development of climate finance funds could legislate to better regulate the activities of multinationals based or operating in their jurisdictions (here, the disclosure requirements imposed by the EU on multinationals go in the right direction, although they remain too limited, they do not take into account developing countries enough, and should incorporate more criteria related to environmental protection).

Second, rich countries aid programs should support and strengthen the negotiating positions of LMICs in international discussions about new taxation regimes, in particular taxes to be imposed on multinational companies. Developing countries lose about US$200 billion a year (compared with US$400 billion per year in high-income countries) through profits shifted to low-tax jurisdictions (IMF, 2015)[14]. Current discussions on the apportionment of multinationals profits, occurring under the auspices of the OECD, could lead to additional government revenues of the order of US$110-160 billion (under so-called Pillars 1 and 2) for both high-income and low-income countries. In the best-case scenario for developing countries, the deal may mean that LMICs can reform their tax systems with more aggressive anti-shifting measures, removing in-

[13] In these discussions, the question of developing countries' sovereign debt must not be forgotten, as excessive debt servicing places further financial strain on developing countries' government budgets.

[14] https://www.imf.org/external/pubs/ft/wp/2015/wp15118.pdf

centives, and introducing minimum tax rates.

However, these proposals have been criticized by developing countries and some experts for allocating relatively few taxing rights to LMICs. It should be noted that LMICs are in general more reliant on corporate taxes than high-income countries: corporate taxes account for 15% of tax revenues in Africa and Latin America, compared with 9% in OECD countries. Strengthening corporate tax rates, rather than reducing corporate tax revenues, therefore seems to be a priority to raise overall tax revenues in LMICs. Developing country concerns include: (i) taxing rights under Pillar 2 (i.e. a global minimum tax) implying that most revenues will accrue to MNE headquarter countries, (ii) the limited share of residual profits available for reallocation under Pillar 1 (i.e. a set of rules to allocate taxing rights over currently untaxed profits), (iii) the limited scope of companies included, (iv) the mandatory removal of digital taxes, which would mean that certain developing countries that have already implemented such taxes, may be net losers under the deal, (iv) the reliance on expensive private sector arbitration in case of disputes, which in the past has often been to the disadvantage of developing countries, (v) the lack of transparency in the negotiation process, and limited capacities to participate in the dealing (McCarthy, 2022).

In the light of this, the Independent Commission for the Reform of International Corporate Taxation (ICRICT) stresses that global minimum tax *"proposals as currently formulated are fundamentally inequitable, in that they give the prior right to apply a top-up tax* (*to the agreed global minimum*) *to undertaxed profits to the home countries of MNEs, while host countries would have only a secondary, back-up right. This would be a direct transfer of revenue from developing countries, which are generally only hosts to foreign MNEs, to the rich home countries."* (ICRICT, 2020). G7 countries alone, representing 10% of the world population, would take more than 60% of Pillar 2 gains (from a global minimum tax) (TJN, 2021). Low-income countries, which lose a higher share of their theoretical tax revenues to corporate tax evasion, would gain disproportionately little from the minimum tax proposed. Such views have been voiced by developing countries themselves, and some, including Kenya, Nigeria, Pakistan and Sri Lanka, have refused to sign on. As of May 2022, only 23 African countries were among the 137 countries and jurisdictions set to implement this global deal, representing less than half of all countries and jurisdictions of the continent (McCarthy, 2022).

Alternative rules can be designed to ensure a fairer allocation of new tax revenues among rich and developing countries. The Tax Justice Network, for instance, proposes a "Minimum Effective Tax Rate" which in the most conservative scenario would involve the same undertaxed profits as in the OECD Pillar 2 (minimum tax) deal, with two variations. First, profits would be considered made in the countries where the MNE's real economic activity takes place (with no distinction between headquarters and host countries), and second, it would be possible to tax the profits at the statutory rate (statutory rates are those announced by countries, which are typically higher than the rates effectively paid by firms after exemptions are applied): this would mean higher additional revenues overall and a fairer global distribution of them. Under this proposal and even with the relatively low rate currently proposed by the deal (that is 15%), low and lower-middle income countries would gain US$26bn instead of US$9bn under the current proposal (as of 2021), according to Picciotto (2021). In particular, India would gain US$13 billion instead of the US$4 billion it could expect under the OECD Globe rules. Sub-Saharan African national revenues would rise from US$2 billion to US$6 billion.

Regarding Pillar 1 (allocation of tax rights based on an apportionment formula), it also appears that the current rules are not at all favourable to developing countries. Using recent data from the European Tax Observatory (Barake and Le Pouhaer, 2022), we find that low-income and lower middle-income countries are clear losers from the tax deal as currently envisaged. More precisely, low-income countries do not receive any additional tax revenues overall (some gain a little while others lose a little). Lower-middle income countries appear to lose slightly in terms of tax revenues. This major concern about the tax deal could be addressed by introducing alternative apportionment rules. Currently based on purely economic indicators such as sales, taxable profits falling under so-called Pillar 1 could be allocated to countries on the basis of social justice principles, or a combination of economic indicators currently envisagef and social justice principles. Factoring in climate risk would for instance significantly change the allocation of new tax revenues, as we show on Figure 35. While low-income and lower-middle countries do not make any gains from new tax revenues in the OECD agreement, they would make 62% gains in an alternative and illustrative approach which would be based on countries' share in vulnerability to climate change risk.

There is obviously no straightforward formula to allocate undertaxed profits equitably across countries and we certainly do not pretend that adopting alternative apportionment formulas is going to be easy. However, current approaches under discussion in official negociations do not appear to be based on justice principles, nor on sound economic principles, as stressed by Nobel laureate Stiglitz.[15] Alternative approaches could factor in countries' exposure to climate change alongside other variables currently taken into account in the OECD deal.

In these discussions, developing countries are usually not well represented at the negotiation table. While the OECD has developed an "inclusive framework" to discuss tax matters in which over 130 countries are in principle represented, the ICRICT has noted, with other organizations, that the LMICs remain poorly represented. To ensure better representation of all countries, the creation of a global tax body under UN aegis has been proposed, which could serve as a novel international norm-setting body , with democratic legitimacy.

Currently, it is unclear for most people in high-income countries how much extra tax revenue will be generated by the new taxing rights environment. In other words, adopting a taxing rights formula more favourable to LMICs may not yet necessarily appear as a loss to taxpayers in rich countries. Certain groups of individuals will inevitably lose from these new tax rules however, but this group remains very limited in size. Shareholders of multinationals would indeed see their profits reduced as corporate tax rates rise. This is a group that has disproportionately benefited from economic growth over the past 40 years and has disproportionately contributed, in part via the capital they own, to global carbon emissions. From this perspective, demanding a higher contribution from these groups to the reduction of global climate inequalities may seem only logical.

While it is not the main role of donor agencies to intervene in such debates in their home country, supporting the strengthening of LMIC tax capacity may actually start at home, in working to change rich countries' national positions on international tax matters. Currently, via their position on international tax reform at the OECD, rich countries continue to defend a new global tax environment that actually undermines the position of LMICs and does not properly integrate a perspective on climate responsibility. The amount of aid they devote to enhancing tax collection capacity in the Global South does not absolve them either. There is a consistency circle to close: international tax reform that more closely matches developing countries' fiscal needs and domestic resource mobilization support will provide the much-awaited boost to adaptation fi-

[15] See ICRICT's September 2022 conference at the Paris School of Economics at this link.

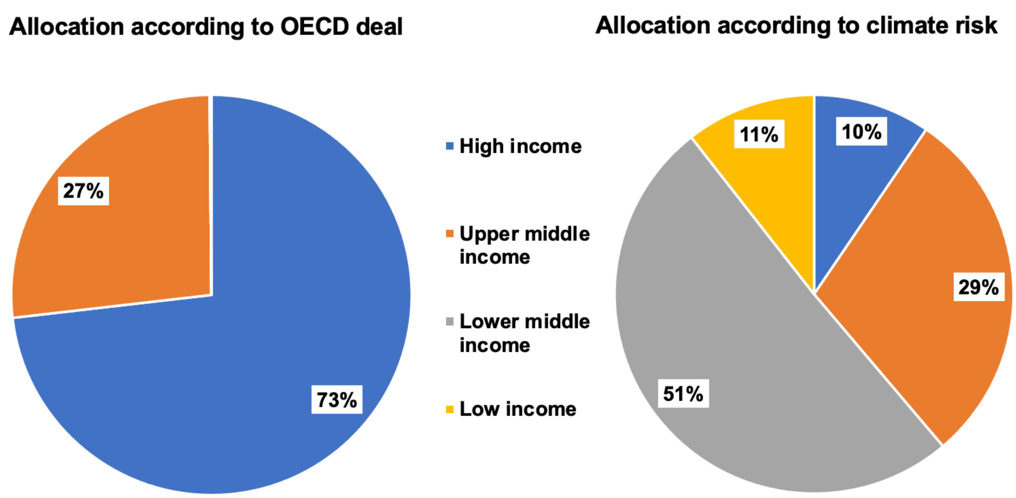

Figure 35: Allocation of new multinational tax revenues: OECD vs climate risk approaches

Notes: The left pie chart shows the allocation of new tax revenues from OECD Pillar 1, based on estimates from the EU Tax Observatory. Total new tax revenues amount to $17 billion. Low middle income countries are net losers (-2% of total gains, not shown here). The right pie chart shows an alternative breakdown, based on a measure of national exposure to climate change. In this scenario, we weight climate according to the INFORM CC Risk database by national population. **Sources**: Authors, using data from Barake and Le Pouhaer, 2022 and INFORM.

nance.

Taxing extreme wealth to fund climate adaptation

We now turn to the critical question of personal wealth taxation. Given the important financing needs for low- and middle-income countries in the coming decades, and given the very large and rising concentration of wealth among a few top holders at the global level, it can easily be argued that the case of progressive wealth taxation has never been so important. How much would a global wealth tax on multimillionaires raise? In Table 36, we present global wealth tax estimates, based on the latest data from the World Inequality Database. We find that a global wealth tax on the world's centimillionaires (i.e. individuals owning more than 100 million dollars net of debt), would raise substantial amounts of money, even when the tax rates are relatively low.[16] This tax would apply to the world's 65,000 richest adult individuals, a group representing just a little more than 0.001% of the global adult population. We consider a relatively modest "1.5% wealth tax for 1.5 řC". It would be designed as follows: net assets owned between US$100 million and US$1 billion are taxed at 1.5%, net assets between US$1 billion and US$10 billion at 2%, assets between US$10 billion and US$100bn at 2.5% and assets above US$100bn at 3%. Let us stress that at these levels of wealth, the per adult net wealth growth observed over the past two decades has been around 7-9% per year (Chancel, Piketty, et al., 2022), meaning that a wealth tax of 1.5% per year would do little to limit extreme capital concentration at the top of the global distribution. A 3% rate as we propose above US$100 billion would have a little more effect, although it would very likely not have been sufficient to limit the snowballing effect of capital accumulation by itself if it had been applied ten years ago. Indeed, all other things being equal, a wealth base growing at 9% before tax, would still grow at 6% per year with a 3% tax rate. Nonetheless, such tax rates, if they were implemented successfully (although even after factoring some capital depreciation and tax evasion) would raise about US$300 billion every year. While it is unlikely that a global deal on a tax on extreme wealth to fund climate change adaptation and mitigation will be obtained in the very near future, such a measure can be initiated by a subset of countries without the need for consensus at Conferences of Parties. For instance, if the US and European countries were to implement such a tax, they would raise about US$175 billion each year, i.e. a substantial amount of money that could fully or partly be redistributed to a global climate fund, at no cost to

[16] Our estimates also take into account potential depreciation of capital due to taxation, as well as tax evasion. See Chancel, Piketty, et al., 2022, chapter 7 for a longer discussion.

Wealth group	Number of adults	Total wealth ($ bn)	Tax rate (%)	Total annual tax revenues ($bn)
All above $100m	65 130	28 141	-	295
$100m-1bn	62 380	15 295	1.5%	109
$1bn-10bn	2 584	8 292	2%	109
$10bn-100b	155	3 181	2.5%	52
Above $100bn	11	1 374	3%	26

Figure 36: Revenues from a global tax on extreme wealth

Notes: The table shows revenues from a global progressive wealth tax centimillionaires. Net wealth between $100m and $1b is taxed at 1.5% per year, net wealth between $1b and $10b is tax at 2%, net wealth between $10bn and $100bn is taxed at 2% and wealth above $100bn at 3%. **Sources**: Authors, based on World Inequality Database (wid.world/world-wealth-tax-simulator/)

99.99% of the population of these countries. It would indeed be preferable that low- and middle-income countries also tax centimillionaires living in their own jurisdictions to fund a global climate scheme. Our tax proposal would, for instance, raise US$121 billion in the US and US$56 billion in Europe. It would also raise US$71 billion in East Asia, US$20 billion in South and South-East Asia, US$11 billion in Latin America and, US$8 billion in the Middle East North Africa, US$8 billion in Russia and Central Asia and US$1 billion in Sub Saharan Africa.

Starting the 1.5% wealth tax at a lower threshold would yield higher revenues. For instance, starting at US$5 million instead of US$100 million, would approximately correspond to the world top 0.1% richest individuals (instead of the top 0.001%). [17] We find that a more progressive wealth tax starting at this threshold would raise about US$1100bn worldwide, that is approximately 1.1% of global income today (see Figure A.5). This amount of revenues is more consistent with total annual climate finance for low and middle income countries excluding China. These are esti-

[17] Under this scenario, we consider a 1.5% marginal net wealth tax rate between US$5m-$10m, 2% between US$10m-$50m, 2.5% between US$50m-$100m, 3% between US$100m-$500m, 3.5% between US$500m-1bn, 4% between US$1bn-$10bn, 4.5% between US$10bn-$100bn and 5% above US$100bn. Assumed depreciation of 10% following wealth tax, and evasion assumed at 20%.

mated at US$1800bn by 2030 as previously discussed. A part of this gap can indeed also be closed by the private sector, but clearly not all of it (Songwe, Stern, and Bhattacharya, 2022).

The main conclusion here is that, given the extreme levels of wealth concentration in the world today, even modest tax rates on top wealth holders can yield substantial tax revenues. For a broader discussion on the rationale behind wealth taxes, their effects on economic activity, we encourage readers to refer to the World Inequality Report 2022, chapter 7 (Chancel, Piketty, et al., 2022). Readers can also design alternative tax schemes for their own regions, playing on tax schedules, and checking the impact of tax evasion and capital depreciation on our online global wealth tax simulator available at WID.world/world-wealth-tax-simulator/.

Who will own low-carbon capital?

Capital ownership is not neutral from the point of view of inequality. Combating climate change will require myriad investments in infrastructure in high-, middle- and low-income countries (see discussion on total finance needs in section 3.1). Which actors should make these investments and ultimately control the capital the investments generate: national governments, local governments, the private sector, or public-private partnerships?

According to the Climate Policy Initiative (Naran et al., 2022), climate finance flows amounted to over US$850bn in 2021, with public finance contributing to about 50% of the total, the rest being private sector finance.[18] In 2011, public sector climate finance amounted to 40% of total flows (see Figure 38). Public sector finance therefore rose faster than the private sector and contributed a greater share to closing the climate finance gap over the past decade. Development finance institutions represented the bulk of public finance, while corporations and commercial financial institutions provided about 80% of private climate finance (Songwe, Stern, and Bhattacharya, 2022). Private finance largely dominates finance flows towards rich countries, while the situation is often reversed in low and middle income countries, where public finance dominates.

How to structure climate finance in the decades to come in order to close the huge climate finance gap (in both developing and rich countries)? Which sector should contribute the lion's share of additional investments and spending needed? There is no easy answer to these questions and each country must

[18] The $850bn figure is provisional according to Naran et al., 2022 and here we estimate the 2021 split based on 2020 values.

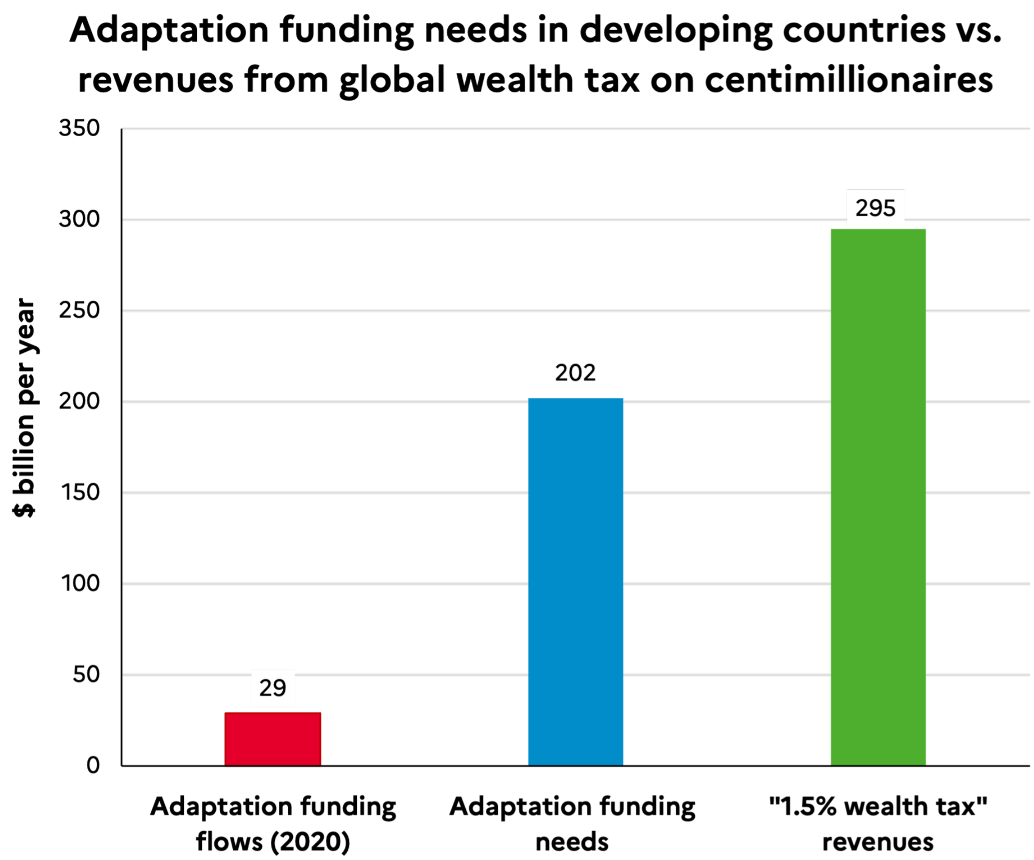

Figure 37: Adaptation funding gap in developing countries vs. 1.5% wealth tax on global centimillionaires

Notes: Adaptation finance flows to developing countries reached US$29bn. Finance needs amount to about $200bn. A wealth tax on centimillionaires could generate US$295bn per year, enough to close the gap and generate additional revenues. Finance needs based on UNEP Adaptation Gap Report 2022 (Table 3.3). Annual wealth tax revenues for 2021, from the World Inequality Database. Wealth tax rates according to Figure 36. **Sources**: Authors based on WID.world and UNEP 2022.

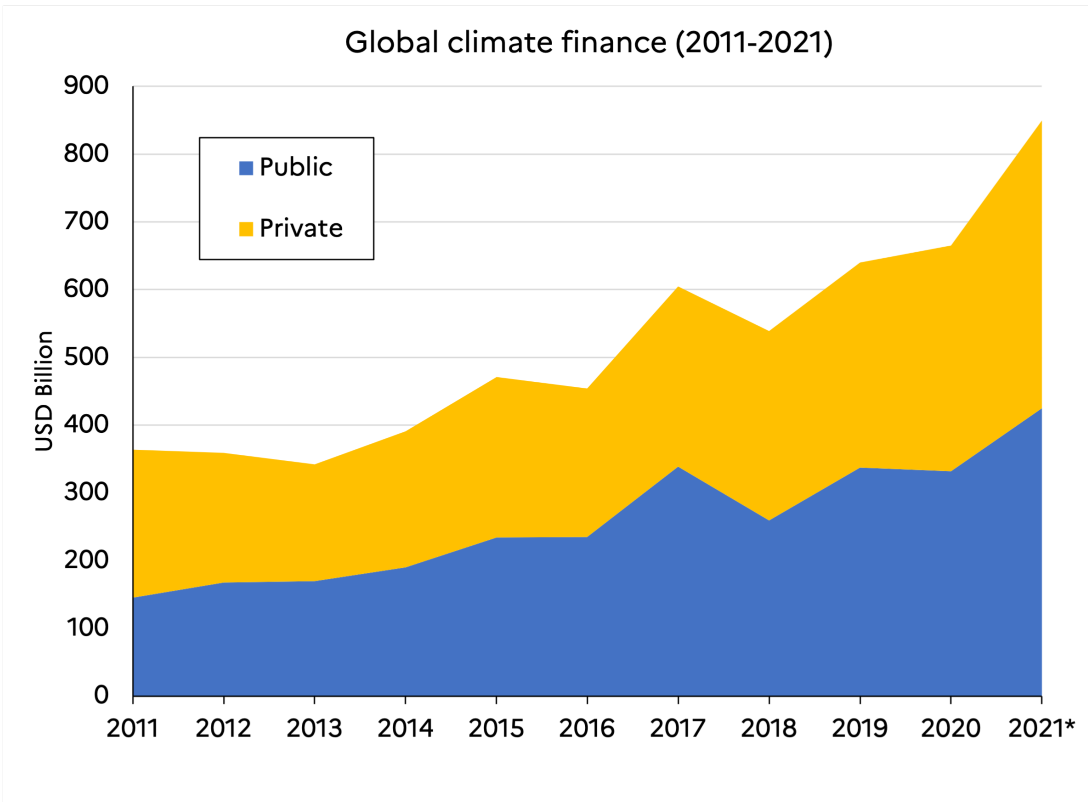

Figure 38: Global climate finance flows: public vs. private sector (2011-2020)

Notes: Global climate finance amounted to $665bn in 2020 and was equally split between public and private institutions. The public sector share has been rising since 2011. The 2021 value is provisional and the split is estimated based the 2020 breakdown. **Sources**: Authors based on Naran et al., 2022.

decide on the basis of the specific technical, economic, and political considerations. From the point of view of inequality, the question of finance and ownership of the capital it supports is never totally neutral. Capital owners can dictate conditions of access to infrastructures, and governments may be better placed to ensure cheap, and universal access to low-carbon transportation, sanitation and energy infrastructure than the private sector. This means that governments and donor agencies should be particularly careful when making decisions about infrastructure ownership, as they may determine access to infrastructure and capital ownership for the next few decades.

Richer countries, poorer governments? Over the past 40 years, an important decline in net public wealth position in high-income countries has been documented. By public wealth, we mean all assets owned by governments (financial and non-financial), net of debts. In LMICs, data is scarcer, but a decline also seems to be observed over the past 10-15 years, while private wealth has typically tended to increase. In other words, countries have become richer, but governments often have become poorer overall.

The multiple investments that will be made in the context of the transition will not be neutral from the the point of view of the relative position of public wealth and private wealth in the economy. The transition could contribute to reinvigorate the position of the public sector, but could also contribute to exacerbate trends observed over the past decades. When analyzing such trends and anticipating the future, it is important to bear in mind that government legislation and policies can determine the relative value of different forms of capital ownership over the coming decades.

It can be argued that private investors should benefit from the low-carbon investments they will make, but that there is a limit to the gains they're able to extract from the transition given the important role of public actors to ensure that the transition actually happens. The role of governments will also be key here to ensure that market gains are not overly concentrated in a handful of actors. In previous historical transition processes, huge monopolistic actors have sometimes emerged, causing issues that took decades for governments to come to terms with. An infamous example is that of Standard Oil in the US, a trust that grew so large that it had to be broken up with Antitrust laws in 1911 as a result of the lawsuit brought against it by the U.S. government in 1906 under the Sherman Antitrust Act of 1890. In post-WWII Europe, governments nationalized energy, infrastructure, and transport companies to avoid such situations, to ensure better planning of reconstruction efforts, and to limit inequalities in societies that had been torn apart by the war. In other words, there are many different possible finance and ownership models for the energy sectors that will emerge in the coming decades, and it is important that the choices about who is going to own what are debated and made explicit.

Some governments will choose private sector finance and ownership of key energy sectors over the public sector. In which case, taxation can be used to redistribute some of the profits made by firms. The rationale behind taxation and redistribution here is that firms will benefit from government intervention in the economy to create a sound environment for their low-carbon energy business to thrive. However, recent research finds that ex-post policies such as taxation are not sufficient to limit extreme inequalities in income and wealth ownership and the fast development of low-carbon technologies can hardly be a legitimate reason for extreme wealth concentration. Limiting wealth inequalities ex-ante (via regulations, antitrust laws, public control of certain firms, etc.) is also key. From such a standpoint, favouring public finance and ownership of capital over the private sector might make sense.

How to conduct such discussions in practice? When developing new climate-related infrastructure, impact evaluation should take into account distributional considerations from a broad perspective: Who will own the infrastructure and how will owners use their property rights in determining prices? Are governments letting monopolistic private actors develop? Have they thought about how to prevent future rent seeking in their adaptation strategies? Via what mechanisms? Again, there are no easy or straightforward answers to these questions, but it is likely that the issues will become more and more important as more finance is directed towards the low-carbon sector. Indeed, it has been shown that inequalities of capital ownership are always more pronounced than income and consumption inequalities, and large capital ownership inequalities today typically mean large income inequalities tomorrow. The matrices at the end of this report are presented to help policymakers to assess the impact on inequality of their climate policies (see Figures 40 and 41).

3.3. Earning more, but also spending better

Learning from attempts to phase out fossil fuel subsidies

The political sensitivity of removing fossil fuel subsidies (FFS) and the difficulties of sustaining and completing them have focused scholarly attention on the hurdles and drivers of reforms. Over the last five years, qualitative case studies have multiplied that can explain why subsidy reforms "stick" (Atansah et al., 2017, Inchauste and D. G. Victor, 2017, Whitley and Van Der Burg, 2015). This research identifies a series of factors that inhibit the removal of FFS, and also some drivers of success. The latest contributions focus on the factors preventing reforming governments from backsliding. We summarize the policy outcomes of these different lines of research in Figure 39.

Indonesia and Nigeria provide an example of contrasting experiences. Using the opportunity offered by declining world oil prices, the Indonesian government managed to cut annual fuel subsidies from US$13.6 billion in 2014 to US$1.6 billion in the 2015 state budget. Support from (part of) the public and compensation programs proved critical to the success of the reform. Unconditional and conditional cash transfers, on the top of pre-existing social assistance programs largely appreciated by the general population, contributed to building trust and eased the reform process. In the space of a decade, the government introduced poverty alleviation programs and social safety nets to help people to cope with energy price increases. Beyond their original mandate, they "represent the building blocks of a comprehensive social welfare system" (MEMRI, 2019).

Nigeria proved much less successful in its numerous attempts to remove fuel subsidies. A striking example occurred on 1 January 2012, when the federal government led by President Jonathan more than doubled the fuel price from NGN 65 to NGN 145 (US$0.41 to US$0.91) per litre in a bid to completely remove the subsidy on refined petroleum products. This led to widespread protests and a ten-day national strike which only ended when the government partially reversed the increase, reducing the price to NGN 97 (US$0.61) per litre. In May 2016, the price of gasoline was increased to NGN 145 (US$0.72) per litre, then to NGN 165 (compared with a global average price of gasoline of about NGN 600). The last adjustment occurred in July 2022, to NGN 179 per litre in a context of a protracted fuel shortage.

In the literature, there is no single paper disputing the fact that the subsidy regime has created economic inefficiency, exacerbated negative environmental and health externalities, and worsened macroeconomic stability. Evidence shows that it has not achieved its desired social benefits, because the subsidies are regressive. Nonetheless, the subsidy regime enjoys widespread popularity in Nigeria as a tangible means by which to redistribute natural resource wealth - the lack of any other visible wealth redistribution explains the popularity of petrol sub-

	Factors
Inhibiting	Lack of information accessible to the general public Lack of trust in the government capacity to redirect FFS savings to social sectors Weak institutional capacities to implement more targeted policies Vested interests and corruption in FFS schemes
Triggering	Early announcement and predictability (communication and consultation) Careful timing (low prices in world market) Upfront mobilisation of resources to fund compensation and accompanying measures Whole-of-government approach for compensation and transition measures
Sustaining	Phasing in and linking FFS removal to wider tax/energy sector reforms Depoliticising fuel prices and transferring control over prices to independent regulators Preempting popular discontent and rapidly demonstrating tangible economic benefits from reform Locking in partial subsidy reforms with subsequent reforms

Figure 39: Factors that inhibit, trigger, or sustain Fossil Fuel Subsidy removal

Notes: The table shows the various factors that may inhibit (e.g. lack of transparent information) fossil fuel subsidy removal, as well as trigger it (e.g. careful policy design) and sustain such reforms (e.g. linking reforms to wider progressive tax reforms). **Sources:** Sources: Atansah et al. (2017), Clements (2013), Inchauste and D. G. Victor (2017), Sivaram and Harris (2016), Araar and Verme (2017), Whitley and Van Der Burg (2015).

sidy. Against the evidence, the fuel subsidy is considered fair in the sense that it is the only way for Nigerians (especially the poor) to benefit from the countrys natural resource endowment. Another key argument that has been made repeatedly is that Nigerians were not against the removal of the subsidy, but that successive governments had not used the additional revenues in ways that were beneficial to large parts of the population (Beaton et al., 2016).

To address these concerns, the Jonathan government launched the Subsidy Reinvestment and Empowerment Program (SURE-P) in February 2012, to cushion the increase in the official petroleum price. The objective of SURE-P was to provide support to various strata of the population through a range of programs, including the financing of infrastructure and job creation for unemployed young people. Yet implementation is incomplete and unpredictable, due to lack of funding, poor targeting, undefined eligibility criteria, lack of monitoring and evaluation (M&E) systems, and absence of a management information system (Bertoni et al., 2016). Cash transfers are primarily implemented at the state level, with low overall reach and limited results from evaluations.

The Buhari government that took power following the 2015 presidential election drafted a National Social Protection Policy (NSPP) - the first in the history of the 4th republic - and sustained its commitment to it throughout its mandate through budget inclusion for social protection worth NGN 500 billion (US.5 billion) per annum. This includes funding for conditional cash transfers, youth employment, school food programs, micro-credit, and education vouchers. About NGN 70 billion (US$345 million) has been allocated for targeted cash transfers (TCTs) per annum. TCTs hence amounted to roughly US$4 per poor person per year.

In December 2021, in the midst of rising food prices and shrinking oil-driven state revenues, the Nigerian government was granted a $800 million credit by the World Bank International Development Association (IDA) to scale up the national social safety net. The credit line is set up to fund targeted, time-limited, cash transfers to 8.2 million poor people, and vulnerable beneficiaries and their families, identified by the National Social Registry in rural areas and the Rapid Response Registry in urban areas - registries without which the idea of targeted cash transfers and social protection in a broader sense could not materialize.

International cooperation around fossil fuels subsidy removal can follow different paths, from awareness raising, and experience sharing to budget support. An initiative worth mentioning is the inclusion of fossil fuel subsidy reform in an ad hoc trade and sustainability agreement. Launched in 2019 at the initiative of New Zealand, the Agreement on Climate Change, Trade and Sustainability (ACCTS) aims at, inter alia, using trade rules to phase out fossil fuel subsidies among the parties to the agreement, namely New Zealand, Costa Rica, Fiji, Iceland, Norway, and Switzerland. It complements another initiative launched by New Zealand a few years earlier, when it established an informal "Friends" group of non-G20 countries to encourage G20 and APEC leaders to act on their commitments to phase out inefficient fossil fuel subsidies as soon as possible. Current members of the Friends of Fossil Fuel Subsidy Reform (FFFSR) are Costa Rica, Denmark, Ethiopia, Finland, New Zealand, Norway, Uruguay, Sweden, and Switzerland. Broadening the country membership of ACCTS and FFSR to include other developing countries would be a step in the right (low-carbon) direction.

Building adaptive social protection systems

In the face of the looming climate crisis and delayed collective action, UNFCCC parties strengthened the adaptation agenda in the early 2010s, regarding as plausible scenarios of temperature increases exceeding 2°C during this century. The Paris Agreement on Climate Change has eliminated their concerns, so that adaptation has become a core component of developing countries climate strategies, as reflected by their nationally-determined contributions.

An inherent difficulty in adaptation funding is the issue of uncertainty. As recalled by R. G. Wood (2011) "Not only is there uncertainty due to the complexity of the climate system and challenges in modelling it, impacts will depend heavily on their interactions with highly complex ecological and socio-economic systems". In the case of smallholder farmers, Wood warns, the impacts of climate change are extremely difficult to predict. The supply of market-based insurance services is all but unlikely, due to this uncertainty. On the demand side, those most vulnerable to climate change are invariably threatened by a whole range of problems, including immediate ones such as hunger, disease, conflict, and price fluctuations, that overshadow considerations about the longer-term issues of adaptation, and eventually depress their willingness to pay for adaption services. This is the classic situation of a market failure.

In developing countries, uncertainty about long-term climate impacts is but one of the many uncertainties that poor people face in a context where market incompleteness is more the rule than the exception. R. G. Wood (2011): "Climate change presents social policy with a dual challenge.[...] Building and extending safety nets in areas which currently lack them and where climate change is likely to increase stresses, whilst simultaneously promoting transformative interventions which reduce the marginalization of the most vulnerable and increase their long-term adaptive capacity".

Cash transfers rank among the means most favoured by governments and donors to address the multiple causes of vulnerability. Although the exact contribution of cash transfers to poverty reduction or livelihood transformation depends on the local and institutional settings, and hence remains an empirical question, it seems positive across the projects examined to date (Asfaw, Davis, et al., 2014, Bastagli et al., 2016, Daidone et al. (2015)).

Cash transfers are a privileged option for what is now labelled "adaptive social protection" (ASP) to cope with crisis and build resilience against a wide range of uncertainties. ASP goes one step further than classical social protection programs by helping to ensure that the latter's crucial human capital investments are not undermined by crisis or shock (World Bank, 2018, Rutkowski, 2018). ASP can help build resilience to climate change by increasing human capital, facilitating changes in economic activities by relaxing liquidity constraints, improving natural resource management, and building local economies. The question is no longer "Are cash transfers good for the poor?" but "Is there a role for cash transfers in building resilience to climate change?" and the answers in the literature seem to lean towards "yes".

Most social protection programs designed to address the impacts of climate change are found in South Asia and East Africa (Asfaw, Davis, et al. (2014), Asfaw, Carraro, et al. (2017))). In Sub-Saharan Africa, the exceptions are Zambia and Ethiopia. In Ethiopia, climate risk adaptation and social protection have been combined through the national Productive Safety Net Program (PSNP), which has increased the food calorie intake of beneficiaries to almost 30% more than non-beneficiary households (Id.). In Zambia, Lawlor, Handa, and Seidenfeld (2015) investigated whether cash transfers allow households facing climate and other negative shocks to avoid negative coping strategies that lead to a poverty trap. Using a randomized roll-out of the Zambian Child Grant Program and 2,515 households to estimate the impact, they found that in the event of shocks, cash payments increase the resilience of poor households. Giving credence to these findings, Asfaw, Carraro, et al. (2017) also present significant evidence that cash transfers in Zambia have mitigated the negative impacts of climate events. This all suggests that cash transfers are an effective policy option for promoting climate-resilient development. In Nigeria, humanitarian and development organizations intervening in the poorest and most vulnerable states of the federation have developed incomparable knowledge on cash transfer programs via vouchers, direct cash, and mobile money (ICRC (2018), Sossouvi (2018)). Global warming could affect the efficacy and magnitude of these programs in states prone to humanitarian crises. Put another way, development programs and policies targeting the SDGs could learn much from the humanitarian aid community for the design of resilient social transfer programs and registries in the context of uncontrolled global warming.

3.4. Towards an ecological welfare state

The contrasting cases of Indonesia and Nigeria are telling about the challenges of crafting and reforming welfare state regimes to address climate change inequalities. Debate on the emergence of a green welfare state or "eco-state" dates back to the late 1980s, with the conflation of rising environmental alarm and the crisis of the welfare state and Fordist accumulation model. Meadowcroft defines the eco-state as "government programs dedicated to controlling environmental impacts and adjusting patterns of socio/ecological interaction to avoid ecological risks and enhance ecological values" (Meadowcroft, 2005).

The rationale for transforming the welfare state into an eco-state lies in the need to manage the environmental risks coming on top of the inter-temporal uninsurable risks and other market failures that are mitigated by welfare states programs. As Koch and Fritz (2014) argue, "not only will social policies need to address the inequalities and conflicts that are likely to emerge in the transition towards more sustainable production and consumption patterns, it will also be increasingly necessary to formulate them in ways that create synergy with environmental goals and that are acceptable to the electorate". They deduce that welfare states, and particularly social democratic welfare states, following the typology proposed by Esping-Andersen (1990), are promising candidates because of their track records on social risk-management mechanisms, conflict resolution, and fair income and wealth distributions. Hence, Gough et al. (2008) argue that "social democratic welfare states have been pioneers in developing comprehensive environmental policies, including climate change mitigation", judging that this edge could be sustained. Gough et al. (2008) arrive at the provisional conclusion that "social-democratic welfare states (. . .) are better placed to handle the intersection of social policy and climate change than the more liberal market economies with more rudimentary welfare states".

Two theoretical arguments underpin the hypothesis of a synergy between social-democratic welfare regimes and eco-states. The first is that the changing climate, adaptive responses to it, and mitigation efforts create winners and losers, so that "an array of policy measures may be needed to cushion shocks imposed on specific societal sectors" (Meadowcroft, 2005). Second, in countries with lower income inequalities and energy poverty, it should be easier to tax and curb energy consumption because of less regressive and perverse distributive effects.

The synergy hypothesis lacks empirical grounding however. The possibility of competition, clashes and conflicts is emphasized by environmental economists such as P. Victor and Rosenbluth (2009), T. Jackson (2016), and Bailey (2015). The literature suggests that there is no "automatic" emergence of the eco-state out of existing welfare institutions.

Voituriez (2020) expands G. Wood and Gough (2006) pioneer typology on welfare regimes in developing countries to include climate inequality variables. Through a cluster analysis (i.e. a statistical method to identify similarities and differences between elements of a set), eco-states are classified along three dimensions: public spending on health and education as a share of GDP, the top 10% to bottom 50% income ratio, and the environment protection index (EPI). Drawing on data from 84 developing countries, four groups emerge.

- A first group of countries displays high state expenditure on health and education, a high degree of inequality, and high environmental performance. This first group outperforms the others on the environment criterion. This group is labelled as "Unequal Eco-states" for their high level of inequality.
- A second group comprises countries with low state expenditure on health and education, high income inequality, and medium-high environment protection. Income inequality in this group far exceeds income inequality in the other groups. This group is labelled as "Super Unequal Eco-states".
- A third group of countries is characterized by low-to-medium state expenditure on health and education, low income inequality, and medium environmental performance. This

is the group with the lowest income inequality. This group is labelled as "Balanced Eco-states" for their medium performance across the whole set of criteria.

- A fourth group comprises countries with the lowest state expenditure on health and education, the lowest EPI, and medium inequality level. The poor performance on the social and environmental criteria merits this group the label "Insecure Eco-states", with reference to Wood and Gough's (2006) typology (Appendix Figure A.2).

Insecure eco-states differ strikingly from "insecure" country regimes in G. Wood and Gough (2006). Their category of insecure welfare regimes encompassed Sub-Saharan African countries almost exclusively, while here, Sub-Saharan African countries and low-income countries more broadly are spread across the four groups. Large emerging economies are to be found in the Insecure Eco-states group: Bangladesh, India, Indonesia, Nigeria, Pakistan, the Philippines. Most of the world's poor live in these middle-income countries, which face the daunting task of reducing inequality at the bottom of the distribution while mitigating environmental risks associated with growth-led poverty reduction strategies. Whether they succeed in transforming from emerging economies into emerging eco-states will be critical for the global achievement of sustainability goals and the Paris Agreement on Climate change.

3.5. Summary: An inequality check for climate & development policies

At a domestic level, the need to take into account the distributive effects (intended or unintended) of climate or climate-related policies has been documented for mitigation and adaptation measures over the last two decades. On the mitigation side, research has particularly focused on the carbon tax and its possible negative effects among those at the bottom of the income distribution - comparing the isolated successful case of Sweden with other countries, in particular large ones where the carbon tax was a decided failure (Andersen, 2019, Criqui, Jaccard, and Sterner, 2019, Sénit, 2012, Sterner, 2020). One of the general conclusions in this research is that any carbon tax should be embedded in a wider set of policies that includes reform of the income tax system and of environmentally harmful subsidies, so that citizens regain trust in fiscal justice. The removal of fossil fuel subsidies is another form of "carbon taxation", and the evidence is mounting that compensating the losers, and a certain degree of trust in the governments capacity to redistribute fairly the amounts saved, are crucial to its success. Lessons were learned as much from the isolated success cases as from the failures.

On the adaptation side, the literature focuses on the unintended consequences of policies and projects, on both climate and social accounts - the concept of "maladaptation" has become a widespread way to describe these unintended consequences (Eriksen et al., 2021, Magnan et al., 2016).

A case-by-case approach seems inevitable, as the inequality dimensions of mitigation and adaptation policies and projects are context-dependent and vary from country to country. However, this does not prevent investigation of the distributional consequences of climate action and sustainable development policies. Providing answers to a question such as "who are the target beneficiaries?" for a given policy, and splitting these beneficiaries among income groups, is becoming easier as the quality and availability of data on economic inequalities increases.

To illustrate, we provide possible answers to this question in the case of an imaginary sustainable energy program (Figure 40) and food policy (Figure 41). The "inequality-check matrix" displayed in these two tables enables us to distinguish the different components of a given development policy in the columns of the matrix (supply, access, scale-up), and in the rows (the target groups or beneficiaries, either intended or unintended).
We use the classifications bottom 50%, middle 40%, top 10% and top 1% as an example. Others can be envisaged, depending on the particular objective of the policy or project and available data.

One possible virtue of these matrices is that they could spark awareness of some inequality effects that would have been ignored otherwise, as it covers the full spectrum of the income distribution. Thus, empty cells would reveal as much as full ones, pinpointing some unknowns in the distributional consequences of climate action. A second virtue is that it could be used as a framework to structure and compare experience among donors across different countries and sector/policies, facilitating the process of learning-by-doing.

		What kind of climate policy?		
		Decarbonize energy-supply	**Increase decarbonized energy access**	**Switch in energy end-uses (building, transport, industry)**
Which social group is targetted?	**Bottom 50%**	Industrial policy: Public investment in renewables (on or off-grid); Social protection: increased transfers to workers affected by the transition	Public investments in low-carbon energy access (e.g. clean cookstoves, zero-carbon social housing)	Develop public transport systems: low-carbon BRT, rail, car-sharing strategies; energy retrofitting in social housing; cash-transfer to compensate increase in fossil energy prices
	Middle 40%	Same as above + Financial incentives to encourage middle-class investments in low-carbon energy. Bans on new fossil investments.	Subsidies for new housing construction; buildings energy regulation; penalty/bans on sales of inefficient housing	Same as above; stricker regulations and taxes on polluting purchases (SUVs, air tickets); subsidies on low-carbon alternatives (elec. vehicles).
	Top 10% & Top 1%	Wealth or corporate taxes with pollution top-up to finance the above & accelerate divestment from fossils; Bans on new fossils investments	Wealth or corporate taxes with pollution top-up (see left); fossil fuel subsidy removal	Strict regulation on polluting purchases (SUVs, air tickets); wealth or corporate taxes with pollution top-up (see left); carbon cards to track & cap high personal carbon footprints

Figure 40: Inequality check for climate policies

Notes: Authors, inspired by Rodrik and Stantcheva (2021).

		What kind of food policy in a context of rising and volatile prices?		
		Climate-proof food supply	**Increase access to sustainable food**	**Scale-up & stabilize supply and access**
Which social group is targetted?	**Bottom 50%**	Public investment in rural transport, irrigation and water management systems Agriculture public development banks to provide loans to the most in need Price support for agro-ecological practices Self-targeted input subsidies Warehouse receipt financing Managing transboundary animal and plant diseases	Cash transfers (targeted/conditional) Self-targeted food-for-work program Food aid Targeted consumer subsidies (short term) Strategic reserves	Establish disaster risks and early warning mechanisms Protect strategic seeds reserves Support water harvesting and conservation Develop indicators and evidence-based early action triggers
	Middle 40%	Same as above + first loss in climate-proofed blended finance vehicles; incentives to invest in climate-resilient agriculture	Import tariff cut VAT cut Consumer subsidy (benefit also the above, but not targeted to them)	Same as above + Support farm and off-farm diversification (benefit also the above but not targeted to them)
	Top 10% & Top 1%	Market-based risk management systems Increase insurance cover against extreme events (benefit also the above but not targeted to them) Wealth or corporate taxes with pollution top-up to finance the above	Permanent excess profit tax, windfall profit tax to finance the above	Wealth or corporate taxes with pollution top-up to finance the above

Figure 41: Inequality check for food and agricultural policies

Notes: Authors, inspired by Rodrik and Stantcheva, 2021.

Summary recommendations

This report has discussed a set of policies intended to boost the adaptive capacity of the most affected and vulnerable populations (through funding and direct interventions in particular in LMICs), delineate equitable mitigation strategies, and facilitate the construction of ecological welfare states. In this light, the following policy interventions appear to be promising points of departure for future development:

Inequality, measurement, and evaluation

- The first main take-away of this report is the need to further mainstream distributional analysis in climate adaptation and mitigation policies, finance programs around the world (in low, middle and high-income countries). The **report provides an inequality-check matrix** for climate policies, which can help project developers and policymakers develop their own distributional impact indicators and evaluate their policies.

- To better integrate inequality concerns and adaptation and mitigation policies, better distributional data is paramount. This report provides some evidence about the interactions between socio-economic inequality as well as GHG pollution, impacts and exposure. Current public statistics on the matter remain incomplete and lag behind the publication of other economic indicators. Significant resources should be **invested in the production of distributional environmental statistics** in all countries.

Inequality and policy design

- Based on recent policy proposals and developments, the report has shown that climate change inequalities can already be reduced via good policy design, i.e. design that explicitly focuses on distributional impacts. The **removal of fossil fuel subsidies**, for example, has been largely debated and supported over the past decade but a lot of work remains in this domain. It could free up considerable resources for more socially targeted adaptive measures. Successful examples, such as the gradual removal of fossil subsidies in Indonesia, show that when accompanied by directed social reforms and assistance to low-income households, possible fuel price hikes do not necessarily result in welfare losses for the poor.

- In addition, the report shows that **targeted cash transfers** appear to be one of the most robust instruments for reducing climate-related inequalities immediately following climate disasters, but have also been shown to be an effective measure for climate-resilient development.

- More generally, ensuring **universal access to clean energy, health care, and education** must be unambiguous objectives of any green development agenda. In other words, combating climate inequalities necessarily goes through development and strengthening of the social state (in rich and poor countries).

Inequality and financing

- Financing the cash transfers and public investments needed to strengthen social policies requires additional tax resources for governments. To this end, high-income countries must live up to their pledges and **further raise international development aid**.
- International aid will not be sufficient to foster the development of ecological social states, however. Profound **transformations of international and national tax regimes** will be necessary to increase the overall progressivity of taxes and ensure that actors who benefit most from economic exchanges contribute a significant share of taxes.
- To this end, we show that relatively modest **progressive taxes on wealth ownership** could yield hundreds of billions of dollars of tax revenues every year given the very high level of wealth concentration. High income countries willing to contribute to global "Loss and Damage" funds as well as global adaptation or mitigation funds should start from such taxes. A "1.5% for 1.5řC" progressive tax on extreme wealth (individuals owning over US$100 million would raise about US$295 billion per year, more than enough to fill the current adaptation gap as reported by the United Nations Environmental Programme.
- Strengthening the position of LMICs in the context of the **overhaul of multinational taxation** also seems necessary. The report shows that LMICs will not benefit much from the recently proposed multinational taxation rules (discussed under the aegis of the OECD). But currently undertaxed global multinational profits could become a sustainable revenue source for LMICs should alternative profit allocation rules be discussed and implemented.
- In addition to an overhaul of the in-

ternational tax regime, national tax systems in LMICs and high-income countries should also be modernized. Many countries still lack progressive **capital income taxes, top inheritance taxes** and progressive wealth taxes which could generate significant revenues to accompany vulnerable groups, without hurting economic growth or the middle class.

- Finally, more sectoral measures are indeed possible to fund adaptation and mitigation without hurting low- and middle-income groups disproportionately. These include the **excess profit taxes currently being debated, as well as proposals in favour of levies on air passenger travel and commercial maritime transport**.

Appendix

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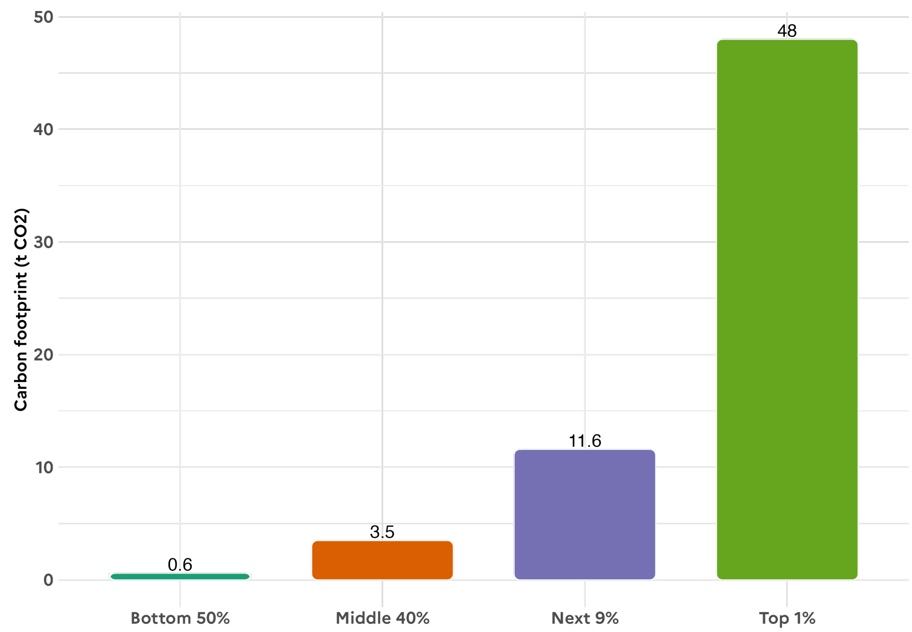

Figure A.1: Carbon Footprint by Emitter Groups based on Bruckner et al. (2022)

Notes: Although based on a different methodology, the results put forward by Bruckner et al. (2022) confirm the general picture shown in Figure 3, i.e. a strong concentration of carbon emissions at the top of the distribution and a comparatively small carbon footprint for the bottom half of the global population. **Sources:** Bruckner et al. (2022)

Cluster 1 **"Unequal"**	Cluster 2 **"Super unequal"**	Cluster 3 **"Balanced"**	Cluster 4 **"Insecure"**
Argentina	Central African Rep.	Albania	Angola
Bhutan	Colombia	Algeria	Armenia
Bolivia	Dominican Rep.	Belarus	Azerbaijan
Botswana	Guatemala	Bulgaria	Bangladesh
Brazil	Honduras	Burkina Faso	Benin
Costa Rica	Namibia	Burundi	Cameroon
Ecuador	Nicaragua	China	Chad
Jamaica	Panama	Congo, Rep;	Comoros
Lesotho	Paraguay	Cote d'Ivoire	Congo, Dem. Rep.
Maldives	South Africa	Djibouti	Gabon
Malta	Venezuela	Egypt	Gambia
Moldova	Zambia	El Salvador	Guinea
Tunisia		Ethiopia	Guinea-Bissau
Uzbekistan		Georgia	Haiti
Zimbabwe		Ghana	India
		Iran	Indonesia
		Jordan	Kazakhstan
		Kenya	Lao PDR
		Kyrgyz Rep.	Liberia
		Lebanon	Mali
		Malawi	Mauritania
		Malaysia	Myanmar
		Mauritius	Nigeria
		Mexico	Pakistan
		Mongolia	Philippines
		Morocco	Sierra Leone
		Niger	Sri Lanka
		Peru	Sudan
		Russian Federation	Tanzania
		Rwanda	Uganda
		Sao Tome and Principe	
		Senegal	
		Serbia	
		Seychelles	
		St, Lucia	
		Tajikistan	
		Thailand	
		Togo	
		Turkey	
		Ukraine	
		Vietnam	

Figure A.2: Typology of Ecostates

Note: Multivariate analysis, k-means clustering, 98 developing countries

Notes: A k-means cluster analysis of 98 developing countries identifies four broad types of ecostates based on the degree of economic inequality, public spending on health and education and environmental performance according to the environmental protection index (EPI). **Sources:** Voituriez (2020).

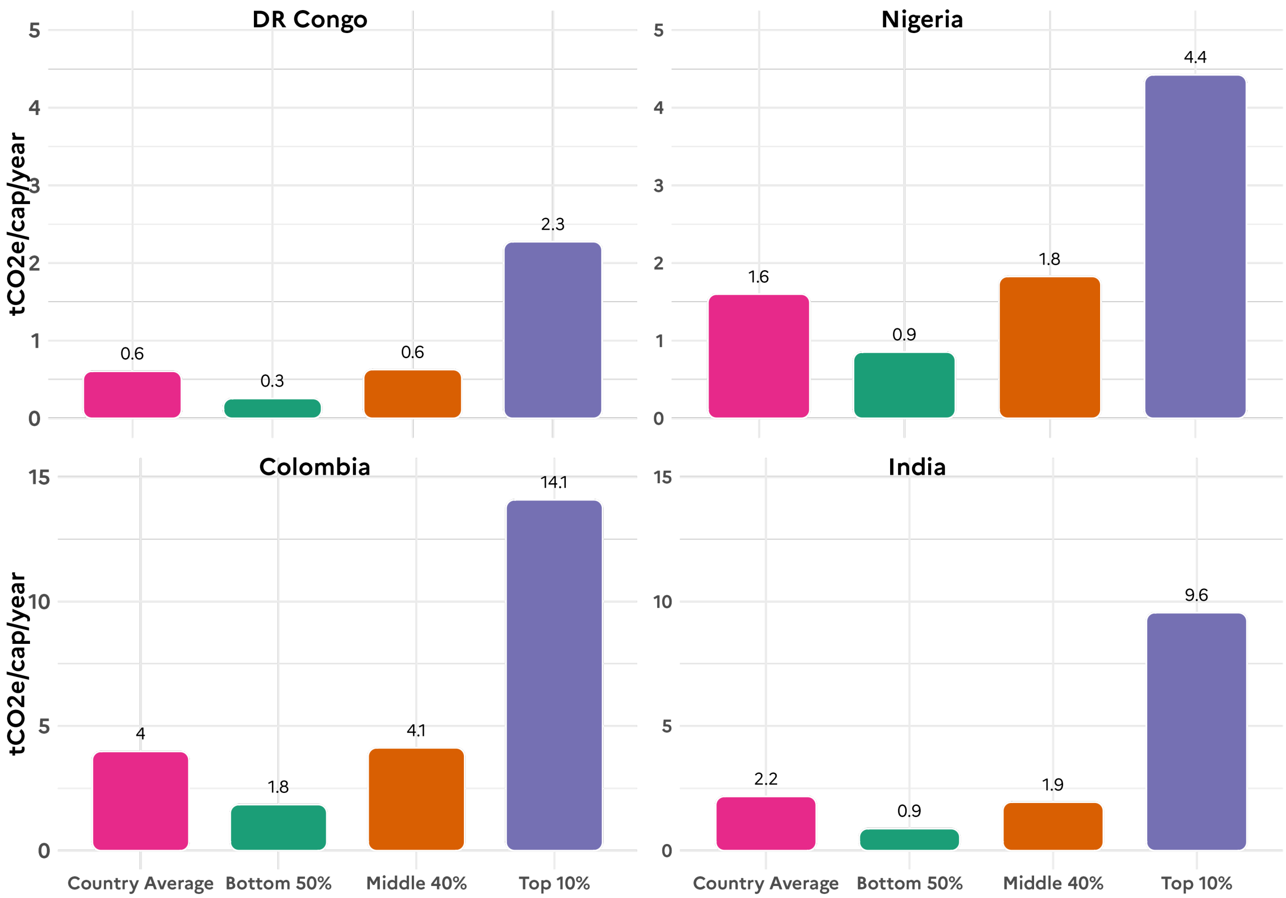

Figure A.3: Per capita emissions of tCO2e/year by population group in developing countries 2019

Notes: The patterns of carbon inequality vary across LMICs. While in some of the poorest countries almost the entire population emits negligible amounts of greenhouse gases, the elites in countries such as India or Colombia make significant carbon footprints. Modelled estimates based on the systematic combination of household surveys, tax data, and environmental input-output tables. Emissions include footprints associated with consumption and investments. Values also take into account the carbon embedded in international trade. **Sources:** Chancel (2022).

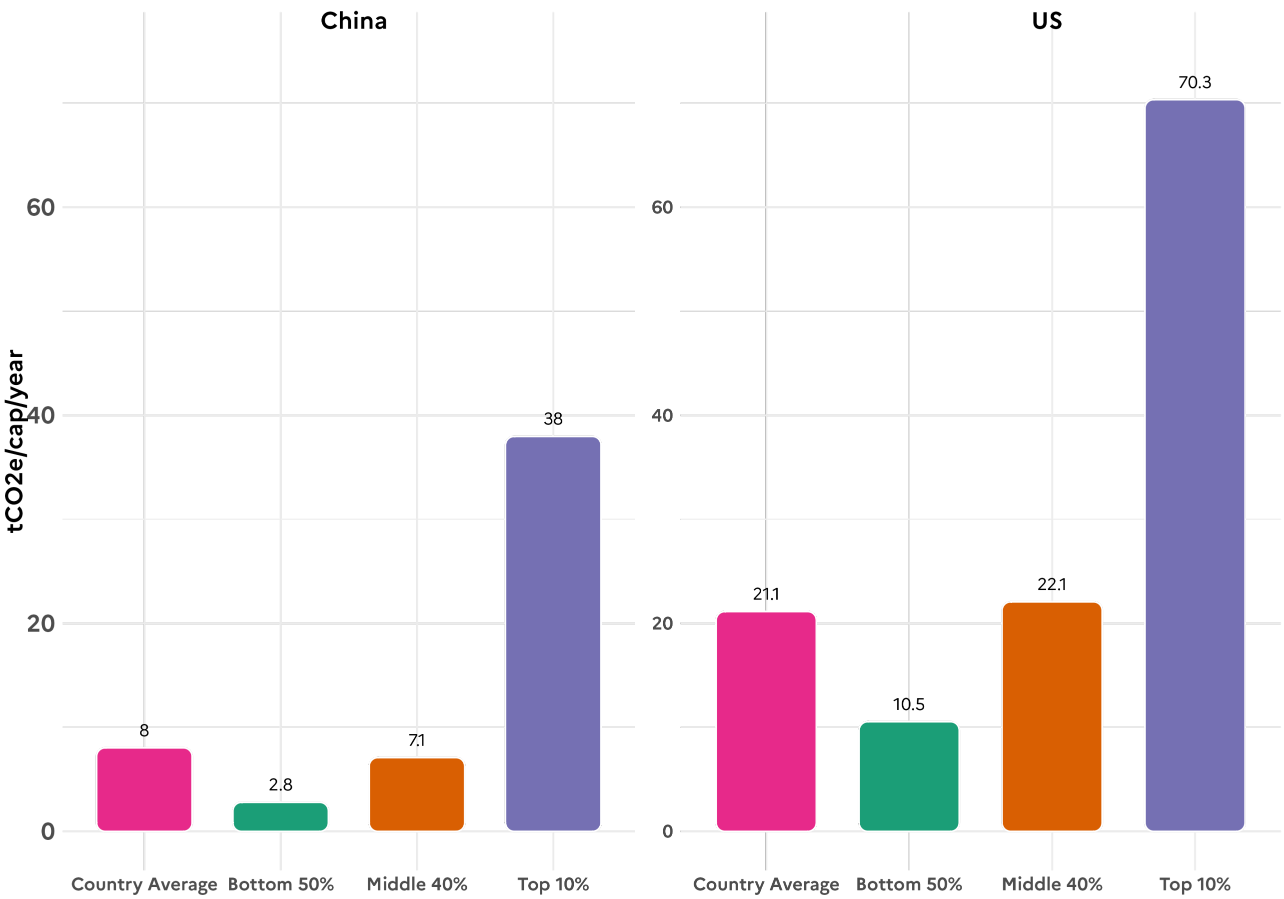

Figure A.4: Per capita emissions of tCO2e by population group in China and the US, 2019

Notes: Inequality patterns also vary across high-emitting countries such as China and the US. In China, high average emissions are largely driven by the top 10% of income earners while the poorer half of the population has a negligible carbon footprint. In the US, the entire population exhibits comparatively high per capita emissions by global standards, yet, the top 10% stand out as having the largest carbon footprint in the world by a wide margin. Modelled estimates based on the systematic combination of household surveys, tax data, and environmental input-output tables. Emissions include footprints associated to consumption and investments. Values also take into account the carbon embedded in international trade. **Sources:** Chancel, 2022.

Appendix notes to figure 29

In this figure, we use country-level GDP losses (in 2030 and relative to a world without climate change) from Burke, Hsiang, and Miguel, 2015. We attribute, to each emitter group within each country, a per capita percentage income loss score. To take into account within-country inequality, we assume that the bottom 40% of the distribution is 20% more exposed to losses than the average population in a given country. We view this assumption as a conservative estimate based on recent studies (see Hallegatte and Rozenberg, 2017 in Figure 26, who find that the bottom 40% is 70% more exposed than the average). The sum of these loss scores, weighted by population, gives a total global relative income loss burden, which is distributed across groups of emitters within each country, making it possible to recover a global distribution of relative income losses. These estimates of the global inequality in income losses should be interpreted with great care given the stylized approach taken to construct them. They nonetheless provide a useful representation of the large global inequality in climate change impacts found in the literature. We stress that these estimates try to avoid one of the many caveats of studies measuring the cost of climate change. In particular, studies often measure costs in absolute monetary terms, and end-up giving much more weight to losses occurring in the Global North. In the graph presented here, what matters is the relative loss (in %) as compared to individuals' income without climate change, so we try to net out this effect.

It should also be noted that the global groups presented on the graph are the same when looking at losses and emissions (more precisely: the bottom 50% of the distribution of losses is constructed in a way that it is exactly the same group as the bottom 50% of emitters). This is not the case for the distribution of wealth holders (more precisely: the bottom 50% of this group is not exactly the same as the bottom 50% of emitters and loss bearers). Although work needs to be done to fully reconcile this kind of datasets, the levels of inequality observed will be very similar. We can assert, with a high degree of confidence, that top 10% emitters, are responsible for a disproportionate share of emissions and at the same time hold an even higher share of global wealth.

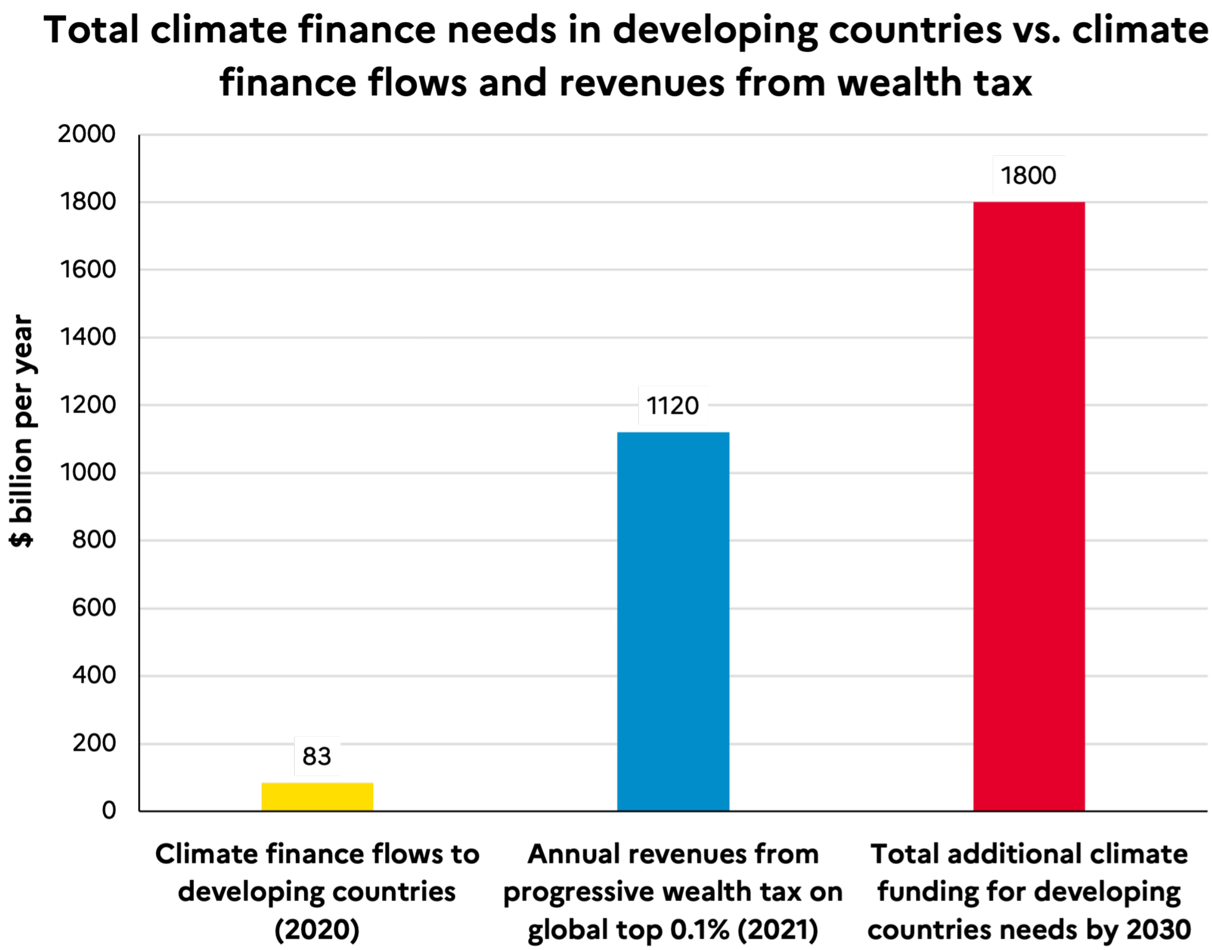

Figure A.5: Total climate funding needs in developing countries by 2030 vs. current finance flows and wealth tax revenues

Notes: The graph shows total annual additional climate funding needs in Low and Middle income countries excluding China by 2030, vs. revenues from a global progressive wealth tax on the top 0.1% (starting at a 1.5% marginal tax rate on net wealth over $5m and up to 5% on net wealth owned over $100bn). **Sources:** Authors based on WID.world, Songwe, Stern, and Bhattacharya (2022) and OECD (2022).

	USD billion	% world GDP
Global climate finance needs in 2023	4200	4.4%
Observed flows (2021)	*850*	*0.9%*
Additional climate finance needs in dev. countries in 2030	1800	1.9%
Observed flows (2020)	*83*	*0.1%*
Adaptation finance needs in developing countries in 2030	202	0.2%
Observed flows (2020)	*29*	*0.03%*

Figure A.6: Annual climate funding needs

Notes: The graph shows annual climate finance needs across different categories. % of world GDP figures based on current world GDP. **Sources:** Authors based on Songwe, Stern, and Bhattacharya (2022), OECD (2022) and Naran et al. (2022).

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