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The Distribution of Climate Finance among Annex-II Countries

A CBDR-RC Approach for Partial Funding of the Developing Countries

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Abstract

Developing nations face the significant challenge of reconciling their efforts in climate change mitigation with the urgent need for financial resources to adapt to climate-related disasters, achieve sustainable development, and stabilize their economies. The financial requirements for addressing climate impacts span various sectors, including energy transition, energy efficiency, transportation, AFOLU and adaptation strategies.

Estimates provided by reputable international organizations, such as IEA, IRENA, and IPCC, suggest that the annual global climate finance needs may range from \$4.2 trillion to \$5.7 trillion. Within this framework, the share allocated to developing countries is estimated to constitute approximately \$1.9 trillion to \$2.0 trillion annually, mainly to support mitigation efforts. It is widely acknowledged that developing countries are unlikely to meet these financial demands independently. Consequently, it is projected that around \$1 trillion must be sourced from advanced economies, particularly the Annex II countries.

This paper introduces a methodology grounded in the principles of CBDR-RC. It facilitates a structured distribution of financing responsibilities among Annex II nations. The methodology incorporates the notion of historical responsibility, quantified as carbon debt, while also measuring capability through a balanced consideration of the wealth and GDP of the Annex II countries. The analysis conducted reveals that the USA is required to contribute nearly half of the total financial obligations among the Annex II countries, with the remaining funds to be apportioned among other nations within this group. This approach underlines the necessity for equitable burden-sharing in addressing the global climate crisis.

JEL Classification:

Q54; Q56; Q58

Key Words

Climate Change, Climate Finance, Climate Debt Trap, Global Climate Crisis, Energy Transition, Carbon Debt, Payer Score Index

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1 Introduction

The crisis of climate change is becoming more and more serious with each passing day. Its impacts are already being felt globally, with a 22% chance that 2024 will become the warmest year on record, and a 79% chance that El Niño will transition to neutral conditions by mid-year. While these crises have affected the global economy, the Global South is affected more than the North due to the already precarious economic and health conditions in these countries. The extent to which individuals, societies, and nations experience the adverse health impacts of climate change will vary depending on their ability to adapt to the stressors imposed by climate change. It's ironic that these vulnerable communities, who have historically contributed the least to current climate change, are disproportionately affected [IPCC, 2021].

From the perspective of the Global South, two demands arise. First, developing countries located primarily in the Global South have aspirations to grow and develop, and hence would need more energy for it. Natural science suggests that energy is crucial to economic production, and ecological economists and some economic historians argue that increasing energy supply has been a principal driver of growth [Stern, 2019]. Second, in the absence of appropriate recognition of equity and international financial transfers from developed countries, some scholars have suggested a unilateral claim to the remaining carbon space as a last resort [Kanitkar et al., 2010, Jayaraman and Kanitkar, 2016]. However, in capturing the carbon space, burning more fossil fuels to meet that energy demand in the South would necessarily lead to higher emissions, which recent research shows is incompatible with the Paris Agreement [Ganti et al., 2023]. So, what's the way out?

One possible solution is that the Global South does not necessarily follow the same trajectory of growth and development as historically experienced in the Global North but heavily relies on an alternative trajectory of growth and development based on a green energy program, which involves the expansion of renewable energy and public

transportation, improvements in energy efficiency, and application of ecological principles for better management of agriculture, forestry, and other land uses. However, the amount of finance needed to achieve the desired levels of development using this alternative green energy path is astronomical and challenging for developing countries to finance them on their own. Furthermore, additional funding is needed for adaptation to protect the communities already experiencing climate change's impacts. In this sense, the developing countries depend on the advanced countries' finances. Therefore, at the 15th Conference of Parties (COP15) of the UNFCCC in Copenhagen in 2009, developed countries committed to a collective goal of mobilizing \$100 billion per year by 2020 for climate action in developing countries in the context of meaningful mitigation actions and transparency on implementation. The goal was formalized at COP16 in Cancun; at COP21 in Paris, this goal was reiterated and extended to 2025. However, as we show later, the advanced countries failed in their commitments.

This paper will focus on the climate finance literature, in general, and, in particular, estimate, relying on the existing literature, the amount of finance needed in the Global South to achieve the goals set in the Paris Agreements: "to keep global temperatures well below 2°C above pre-industrial times while pursuing means to limit the increase to 1.5°C." The paper is structured as follows: the next section discusses the commitments made by developed countries to provide and mobilize funds for developing countries and their current status. However, the current commitments are below what is needed to meet the target of keeping the global temperatures under 1.5°C, if not at least 2°C. The third section provides our estimates, based on the recent IPCC report and other studies, of the amount of climate finance needed by developing countries from the developed world to meet the targets. However, the critical question remains: which developed country takes up how much responsibility for these funds' transfers to the developing countries because, to the best of my knowledge, there are currently no formal guidelines for it? The fourth section addresses this question by formulating a methodology based on the UNFCCC principle of the Common But Differentiated Responsibility and Respective Capabilities (CBDR-RC) to propose a formal guideline for the distribution of commitments. The penultimate section of the paper reports the results. Every crisis presents an opportunity to move beyond the past; the final section summarizes the paper with this perspective.

2 A Background to the Climate Finance

From a climate policy perspective, climate finance refers to finance ‘whose expected effect is to reduce net GHG emissions and/or enhance resilience to the impacts of climate variability and projected climate change’ [United Nations Framework Convention on Climate Change (UNFCCC), 2018]. While the exact definition of climate finance is not universally agreed upon, it generally refers to the financial resources dedicated to combatting climate change by both public and private entities on a global to local scale [IPCC, 2021, p.2902]. This includes international financial aid provided to developing countries to support their efforts to address climate change. The objective of climate finance is to reduce net greenhouse gas emissions and/or improve the ability to adapt to and withstand the effects of climate change. Funding may originate from public or private sources, be routed through various intermediaries, and take the form of grants, concessional and non-concessional debt, or internal budget allocations.

Therefore, in the broader sense, climate finance is the term used to describe the local, national, and transnational financing that is drawn from a variety of sources, including public, private, and alternative options. Its aim is to support actions that mitigate and adapt to the effects of climate change. The Convention, Kyoto Protocol, and Paris Agreement all call for financial aid to be provided from countries with greater financial resources to those less fortunate and more vulnerable. This is because the ability of countries to contribute to climate change and their capacity to prevent it and deal with its consequences varies greatly. These countries were the Annex II Parties, which refer to the countries that belong to the OECD members of Annex I, with the exception of the economies in transition (EIT) Parties. These countries are responsible for providing financial resources to aid developing nations in their efforts towards reducing emissions and adapting to the negative impact of climate change. Furthermore, they must make all possible efforts to encourage the development and transfer of eco-friendly technologies to EIT Parties and developing countries. The financial support provided by Annex II Parties is mostly channeled through the Convention’s financial mechanism.

Mitigating climate change requires significant investment, and climate finance is crucial in making this happen. At the same time, it is equally important for adaptation as financial resources are needed to deal with the adverse effects of climate change and reduce its impacts. The Annex II Parties have a responsibility to provide financial resources to assist developing country Parties in implementing the objectives of the

UNFCCC, in line with the principle of “common but differentiated responsibility and respective capabilities (CBDR-RC)” set out in the Convention. Furthermore, the Paris Agreement reaffirms this obligation and encourages voluntary contributions from other Parties for the first time.

2.1 Total Climate Finance Flows and Commitments

The Intergovernmental Panel on Climate Change in its Sixth Assessment Report [IPCC, 2021, Chapter 15] made some important observations about the current status of climate finance globally. It’s important to highlight some of these important observations of the committee so as to understand the current status and the need for future climate finance, which would be important in the context of understating the objective of this research. First and foremost, it is important to recognize that reducing greenhouse gas emissions and improving resilience to climate change impacts are crucial for a low carbon transition, and financing plays a significant role in achieving this. However, there are significant disparities in access to finance and its terms and conditions, as well as differences in countries’ exposure to physical climate change impacts, which could lead to an unequal global transition.

Second, the current pace of implementing climate finance commitments by countries and financial system stakeholders is slow. This slow pace does not reflect the urgent need for ambitious climate action or the economic benefits of such action.

Third, implementing an ambitious global climate policy coordination and increasing public climate financing during this decade (2021-2030) can have a positive impact on macroeconomic uncertainty of developing countries after the COVID-19 pandemic. Moreover, this move can facilitate the redirection of capital markets and overcome obstacles related to the need for simultaneous investments in mitigation while also mitigating the upfront risks that prevent economically viable low-carbon projects.

However, in reality, as a result of the recent pandemics, a worldwide economic decline, and worsening environmental disasters such as droughts and floods caused by climate change, several underdeveloped nations are now facing the challenge of managing their budgets more tightly and are in danger of defaults. Nonetheless, these economies also aspire to invest in for economic development, social protection, pandemic preparedness, emissions reductions, and building resilience to the mounting impacts of climate change; but constrained budgets limit their ability to do so. This vicious circle is usually known as the

climate debt trap in the literature [Ameli et al., 2021]. Unfortunately, the global ramifications of this can be severe, as more frequent and severe disasters fueled by rising temperatures can exacerbate other hardships in health, food insecurity, and economic outlook. This, in turn, can lead to decreased tax revenues and productivity, ultimately diminishing long-term growth prospects. As a result, sovereign credit ratings can fall, and borrowing costs rise, making it more expensive to fund these important much-needed public investments [Alayza et al., 2023].

The IPCC suggests that in order to tackle the current climate crisis, low-income and vulnerable countries should receive increased financial and technical support and partnership from the advanced economies. In Article 9 of the Paris Agreement, it is stated that developed countries must provide financial resources to help developing countries with both mitigation and adaptation, in line with their existing commitments under the Convention. Other Parties are urged to voluntarily offer or continue to offer such support. Additionally, low-income countries such as those in sub-Saharan Africa should have access to ‘preferred’ finance to facilitate low-carbon energy transition. Currently, these countries receive less than 5% of global climate financing flows [MassonDelmotte et al., 2021]. Hence, there is a growing consensus even in the mainstream economic discussions that these vulnerable, low-income economies cannot self-finance the large-scale investments involved in climate finance.

In this context the role of the Annex II countries become vital.¹ Annex II Parties were decided in the United Nations Framework Convention on Climate Change (UNFCCC), which is an international treaty created at the 1992 UN Earth Summit in Rio de Janeiro to stabilize greenhouse gas concentrations in the atmosphere. These nations are obligated to furnish financial resources to aid developing countries in carrying out emissions reduction initiatives under the Convention. They also have a responsibility to assist in the adaptation to detrimental climate change effects. Furthermore, these countries are also required to take practical measures to encourage the advancement and dissemination of eco-friendly technologies to the EIT Parties and developing countries. There is a growing consensus, even within the mainstream, that the

¹ There are 23 Annex II countries plus the European Union. These countries are classified as developed countries which pay for costs of developing countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States of America.

developing countries would need both technical and financial assistance from the advanced ones, and the need of this fund keeps increasing. In his opinion piece in the *Financial Times* (dated: July 11, 2023) titled “The west must recognise its hypocrisy,” Martin Wolf argues:

If emissions are to decline rapidly, while emerging and developing countries still deliver the prosperity their populations demand, there must be a huge flow of resources towards them, not least to finance climate mitigation and the necessary adaptation to higher temperatures.

Although the advanced countries had made similar commitments in the past, but the governments in the advanced countries failed to deliver. For example, during the 15th Conference of Parties (COP15) of the UNFCCC in Copenhagen in 2009, in decision 2/CP.15, in the context of meaningful mitigation actions and transparency on implementation, developed countries agreed to mobilize a collective amount of \$100 billion per year by 2020. The purpose of this financial commitment was to support climate action in developing countries, in conjunction with meaningful mitigation measures and transparency in implementation. However, in none of the years, the developed countries delivered on this promise [OECD, 2023].

In 2015, in Paris, under decision 1/CP21, paragraph 53, the COP extended the goal of mobilizing jointly \$100 billion through 2025. It was also decided that before 2025, the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA) shall set a new collective quantified goal (NCQG), starting from a minimum of \$100 billion per year, while considering the needs and priorities of developing countries. Despite these commitments and extensions, the advanced countries could not meet these goals till 2021. As shown in Figure 1, even in 2021, the climate finance provided and mobilized by developed countries for developing countries fell short by \$10.3 billion of the \$100 billion annual goal that was to be reached by 2020. The OECD has claimed that the developed nations may have achieved their commitment of \$100 billion in 2022. However, these OECD figures too are overestimates, as claimed by other studies, which argue that the net financial value of climate finance to developing countries - the grant equivalent - is less than half of what is reported by the developed world [Carty et al., 2020].

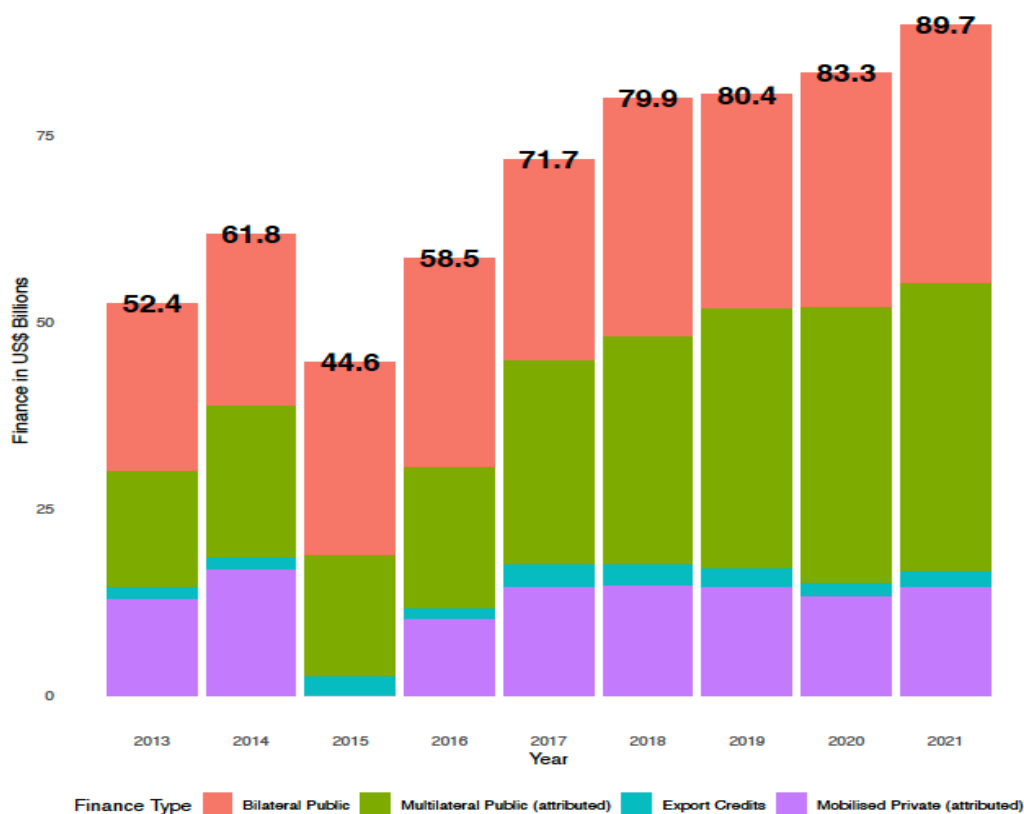
Although there is a recipient country grouping, with 43% of the finance allocated to the low middle income countries (LMIC), but there is no mechanism in place on how the responsibility of the committed finance gets distributed among the developed countries. These rich countries did not reach a formal agreement on their individual financial contributions. Instead, they made pledges with the expectation that other nations would do the same. Various assessments of what would be a fair share for these payments all lead to the same result: the United States has not met the expected level of contribution [Timperley, 2021]. The important question remains that which developed country takes up how much responsibility for transfer of funds to the developing countries? This paper addresses this question and proposes a noble methodology for distribution of responsibility among the advanced countries of the much-needed funds for the developing countries. This should help to develop an international strategy of distribution among the advanced countries, especially, if the governments in advanced countries are serious about fighting climate change and keeping the global temperatures under 1.5°C ; if not, at least 2°C .

2.2. The Estimates of Climate Finance

As the climate crisis intensifies, there is a growing acknowledgment within policy circles of the heightened necessity for climate finance. The push for climate finance is gaining momentum, with the first-ever Global Stocktake in 2023 under the Paris Agreement calling for increased climate finance, the G20 leadership emphasizing sustainable finance, and continued demands for reforming international financial institutions. It is undeniable that during the 2021-2022 period, the average annual climate finance flows nearly doubled, reaching almost \$1.3 trillion compared to \$653 billion in 2019-2020. This surge was primarily attributed to a substantial increase in mitigation finance, as well as methodological enhancements and new data sources contributing to the observed growth [Buchner et al., 2023]. However, despite the growth, the current flows represented only about 1% of global GDP in 2021-22.

Notwithstanding the recent progress in climate finance and emerging solutions, there is an increasingly urgent need for additional funds. There exists a significant disparity between the required funding and the actual global mobilization of resources. Various international organizations and bodies have emphasized the growing demand for climate funds and share the common concern that delaying meeting the total climate investment needs will lead to higher future costs, both in terms of mitigating global temperature rise and

addressing its impacts. In this discussion, we will briefly outline the existing estimates in the literature before presenting our own.



Source: OECD (2023), Climate Finance Provided and Mobilised by Developed Countries in 2013-2021

Figure 1: Climate Finance for Developing Countries

2.2.1 Estimates from the literature

In their latest report, the Intergovernmental Panel on Climate Change (IPCC) provided estimates for the required global climate finance for the first time. According to their findings, the annual average low-carbon investment needs until 2032 for electricity, transportation, AFOLU, and energy efficiency measures, including industry and buildings, are projected to range between 3% and 6% of the world's GDP [IPCC, 2021, p.1573]. Within that, the IPCC estimates that annual investment needs in the energy sector could range from \$0.8 to \$1.5 trillion till 2032 to achieve net zero scenarios by 2050. Additionally, the annual average financing needs for energy efficiency range from \$0.5 to \$1.7 trillion, for transport it is around \$1.0 to \$1.1 trillion, and for AFOLU, the IPCC recommends \$0.1 to \$0.3 trillion. Therefore, based on the IPCC's assessment, the average annual global financial needs for low-carbon investments, which includes energy transition and

improving efficiency, are estimated to range from \$1.3 trillion to \$3.2 trillion.

In 2021, the International Energy Agency released its “Net Zero by 2050: A Roadmap for the Global Energy Sector” outlining a feasible yet challenging path for the global energy sector to achieve net zero emissions by 2050. The ambitious transformation of the global energy system necessary to achieve net-zero CO_2 emissions by 2050 relies on a substantial increase in investment and a significant shift in capital allocation. The roadmap projects a substantial rise in annual clean energy investment, from its current level of just around \$1.2 trillion globally on average from 2016-2020 to nearly \$4.3 trillion by 2030 and \$ 4.1 trillion in 2050[IEA, 2021, ES, p.12]. According to IEA, this represents, in the net zero emissions (NZE) scenario, the total annual capital investment in energy increases from approximately 2.5% of global GDP in recent years to about 4.5% in 2030 before returning to 2.5% by 2050[IEA, 2021, p.81].

The International Renewable Energy Agency (IRENA) also contends that the gap between current achievements and necessary targets is widening, presenting a substantial challenge in meeting the emission reduction goals established by the Intergovernmental Panel on Climate Change (IPCC) for 2030 and 2050. IRENA has recently revised its estimates for the investments required to limit global warming to $1.5^{\circ}C$ by 2050. To achieve the $1.5^{\circ}C$ trajectory, an additional \$47 trillion of investment is needed by 2050, amounting to a cumulative investment of \$150 trillion. In this scenario, transition technologies and infrastructure would require investments averaging \$5.3 trillion per year, which represents a \$1.7 trillion increase annually compared to their Planned Energy Scenario [IRENA, 2023, p.142–168].

IRENA estimates that 47.0% of the total investment required by 2050 would be allocated to transition technologies, totaling \$73.0 trillion, or about \$2.6 trillion annually. This encompasses investments in conservation and efficiency (\$1.5 trillion annually), electrification (\$0.6 trillion annually), production and direct use of renewable technologies (\$0.2 trillion annually), green hydrogen (\$0.2 trillion annually), and carbon removal (\$ 0.1 trillion annually). Additionally, cumulative investments in the transition to renewable power generation capacity and enabling infrastructure would necessitate an annual spending of \$2.2 trillion, with \$1.4 trillion for renewable power generation capacity and the rest for enabling infrastructure. The remaining funds would be directed towards fossil fuel infrastructures, including nuclear power generation.

There have been other estimates, which are much higher than those mentioned in these three studies. Some studies estimate annual climate finance needed through 2030 spans from \$8.1 to \$9.0 trillion in the average scenario. Subsequently, estimated needs jump to over \$10.0 trillion each year from 2031 to 2050 [Buchner et al., 2023, p.3]. This implies that climate finance must increase by at least five-fold annually as quickly as possible to mitigate the worst impacts of climate change. However, other studies also argue a lower estimates. The Rockefeller Foundation and Boston Consulting Group estimated that in order to attain net zero for 2050, global public and private sector organizations will require an estimated \$3.8 trillion in annual investment flows until 2025. However, only a small portion of this capital is currently getting utilized [Kozloski et al., 2022]. On average, from the various studies, one can, therefore, argue that the projected climate finance need for the needed energy transition and related infrastructure development in the global economy ranges from \$4.0 to \$5.0 trillion per annum till 2050.

2.2.2 Our Estimates based on the IPCC report

We have utilized two key pieces of information from the recent IPCC report to estimate the global climate finance required to address mitigation through energy transition and related infrastructure development. Firstly, the estimated mitigation financing needs for developed countries are approximately 2-4% of the average GDP from 2017-2021, while for developing countries, it is around 4-9% [IPCC, 2021, p.1577]. Secondly, developing countries need a four to seven-fold increase in climate finance, whereas developed countries require three to five times more. This gap widens when considering adaptation, infrastructure, and SDG-related investments [Jean-Charles Hourcade and Ghersi, 2021]. Table 1 presents the global finance estimates, including those for Annex II and non-Annex II countries. Our calculations reveal that the total global climate finance requirement, primarily for mitigation, is approximately \$3.9 trillion annually, with non-Annex II countries accounting for almost half of this amount, at \$1.9 trillion. When factoring in the adaptation needs of developing countries, the climate finance requirement for these nations increases.² Consequently, our estimates in Table 1, which primarily focus on mitigation and related infrastructure development, are at the lower end compared to other estimates in existing literature.

² The new assessment estimates that the costs of adaptation for the global economy ranges from \$0.1 to \$0.98 trillion/year, while for the developing countries it will be in a plausible central range of \$0.2–\$0.4 trillion/year for this decade [United Nations Environment Programme, 2023].

Our assessment of the \$1.9 trillion required annually by the non-Annex II countries aligns closely with estimates from other independent studies and reports. Songwe et al. [2022] project that emerging markets and developing countries, excluding China, will need to invest approximately \$1.0 trillion annually by 2025 (4.1% of GDP compared to 2.2% in 2019) and around \$2.4 trillion annually by 2030 (6.5% of GDP). Another independent study conducted by the global management consulting firm McKinsey indicates that developing countries will require about \$2.0 trillion in additional financing per year by 2030 to meet the goals of the Paris Agreement and limit warming to 1.5°C above pre-industrial levels [Daharwal et al., 2023].

Considering the substantial demand for climate finance in the global economy, there is a growing consensus, as previously discussed, that developing countries cannot solely finance all these climate-related initiatives. Additional substantial support is necessary for developing countries to achieve their climate objectives. In estimating the amount of external financial assistance required by developing countries from Annex II countries, we assume, based on the existing literature, that these countries need to generate nearly half of the necessary financing through domestic resources, while the remaining half must be sourced from the rest of the world, especially the Annex II countries.³ Daharwal et al. [2023] and Songwe et al. [2022] also make similar assumptions, positing that 40.0% and 50.0% of the required climate finance could come from domestic resources in the developing world. According to our calculations, assuming that half of the funding is secured through domestic resources, the external funds needed from advanced countries amount to approximately \$950 billion, which closely aligns with the \$1.0 trillion estimate of Songwe et al. [2022].

Table 1: Estimates of Global Climate Finance Needs based on Global GDP

Categories	Figures in \$ (2015) trillion
GDP of Annex II countries	62.2
GDP of non-Annex II countries	24.2
<i>GDP of the World</i>	86.4
Average CF Needs of Annex II countries	2.0
Average CF Needs of the non-Annex II countries	1.9
<i>Average CF Needs of the World</i>	3.9

Note: CF denotes Climate Finance needs for energy transition and related infrastructure developments to primarily address mitigation.

Source: Author's calculations based on IPCC reports and World Development Indicators (World Bank).

³Depending on their individual economic capacities, these non-Annex II countries can mobilize their total domestic resources through public or private investments or any combination of both.

As previously discussed, the advanced countries have not fulfilled their earlier commitment of \$100 billion. One of the primary reasons for this failure is the absence of a formal commitment of funds or a specific distribution plan within the advanced countries. Without these measures in place, it had been easier for advanced countries to evade their responsibility of providing the necessary climate finance to the global South. Therefore, it is difficult to believe that these countries, having previously failed to honor their commitments, would willingly contribute \$1 trillion annually over the next decade, especially considering that the required amount has increased tenfold. Consequently, it is important to establish a strong framework for distributing financial commitments among developed countries to ensure accountability, transparency, and mutual trust between the global North and South. Section 3 presents a methodology for distributing financial commitments among Annex II countries based on the UNFCCC's framework of Common But Differentiated Responsibilities and Respective Capabilities (CBDR-RC).

3 Methodology

The parties to the Paris Agreement in Article 2.1(c) committed in “making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development,” and in particular, the signatories to the agreement signed that “This agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.” This principle, therefore, in essence, refers to the fact that the climate change problem “affects and is affected by all nations in common, if not to the same degree, and that the resulting ‘responsibilities’ ought to be differentiated because not all nations should contribute equally to alleviate the problem” [Yamin and Depledge, 2004]. As we show later in section 4 that the Annex II countries bear the primary responsibility for climate change due to their significant historical contributions to greenhouse gas emissions. As a result, the commitments of both developed and developing countries to substantive and procedural rules are structured in a way that acknowledges their differing responsibilities and capacities [WANG and GAO, 2018].

We propose a methodology that integrates the fundamental principle of common but differentiated responsibilities and respective capabilities (CBDR-RC) established by the UNFCCC in 1992 and upheld by the Paris Agreement 24 years later. This approach places a strong emphasis on the equitable distribution of responsibilities, particularly among the

developed world, with a focus on the Annex II countries. In this study, the historical responsibility of Annex II countries is encapsulated by the idea of carbon budget and carbon debt, while the capability aspect is quantified using two crucial concepts: (a) wealth, which encompasses the historical accumulation of income over time, and (b) gross domestic product, representing the current flow of income in these economies. First, we briefly discuss each of these variables used in the study.

Carbon Debt: The most recent report from the Intergovernmental Panel on Climate Change (IPCC) revealed that from 1850 to 2019, we have already emitted about four-fifths of the total amount of carbon dioxide that would allow us a 50–50 chance of limiting the global temperature increase to 1.5°C since preindustrial times, as outlined in the 2015 Paris climate accord [IPCC, 2021, p.6]. The report suggests that to maintain this 50–50 chance, we can only emit approximately 500 more gigatons of carbon dioxide, and 1150 more gigatons of carbon dioxide for a probability of 67% for limiting warming to 2°C. However, recent studies indicate that the remaining carbon budget for a 50% likelihood of limiting global warming to 1.5, 1.7, and 2°C has been reduced to 75 gigatons of carbon (275 *GtCO₂eq*), 175 gigatons of carbon (625 *GtCO₂eq*), and 315 gigatons of carbon (1150 *GtCO₂eq*), respectively, starting from the beginning of 2024. This reduction is equivalent to around 7, 15, and 28 years, assuming 2023 emission levels [Friedlingstein et al., 2023]. This carbon budget does not account for other greenhouse gases or the cooling impact of aerosols, among other factors. Nevertheless, as carbon dioxide is the most prevalent greenhouse gas, this budget still provides a strong indication of our remaining emissions capacity.

So, what is carbon debt? The concept of carbon debt, climate debt, and ecological debt emerged in the late 1990s within international climate politics, advocated by non-governmental organizations (NGOs) such as Acción Ecológica and Christian Aid [Roberts and Parks, 2006]. These concepts assert that the Global North owes the Global South a climate debt due to its disproportionate use of atmospheric space without payment. This debt encompasses two main components: an “emissions debt,” representing the fair share of atmospheric space owed to developing countries, and an “adaptation debt,” which constitutes compensation owed to enable developing countries to adapt to climate impacts not of their making [Khan et al., 2020]. In this paper, we focus on the concept of “emissions debt.”

To illustrate it, let’s take a country — the United States of America (USA) — as an

example. Between 1850 and 2019, the world emitted 2516 *GtCO₂eq* of greenhouse gases. Out of the total global greenhouse gas emissions between 1850 and 2019, the United States of America (USA) is responsible for 22.0% (553 *GtCO₂eq*), despite representing only 4.3% of the global population. If the emissions were limited solely to the proportionate carbon space allocated based on the global population supported during this timeframe, the United States would have contributed approximately 108 *GtCO₂eq* in greenhouse gas emissions. This underscores the significant disparity between actual emissions and those that would align with a fair distribution model based on global population metrics. Consequently, one can then estimate that the USA holds a carbon debt of 445 *GtCO₂eq* to the rest of the world for its over-emissions during this period. With the remaining global carbon budget for a 1.5°C target set at 500 *GtCO₂eq*, the USA's per capita fair share would amount to 21.5 *GtCO₂eq*. Even without considering past emissions and assuming immediate linear reductions, the USA must achieve net-zero *CO₂* emissions by 2025 to stay within its fair share of the remaining global carbon budget - this, as we can all understand, seems totally implausible [Friedlingstein et al., 2023]. Therefore, the USA's pledge to achieve net zero emissions by 2050 is deemed inadequate and incompatible with the targets of the Paris Agreement, highlighting the urgent need for a reassessment of its climate policies and immediate, drastic action to reduce carbon emissions. Alternatively, the USA can compensate for its carbon indebtedness by taking up the responsibility of providing funds to help in the transition of the Global South.

The disparity in carbon emissions between countries in the global North and South has been a source of concern with regards to climate justice. The over-emission by countries in the North, juxtaposed with the under-emission by countries in the South, has raised serious questions of fairness and responsibility in addressing the global climate crisis. One proposed solution is for the North to offset its excess emissions through net-negative emissions. However, the current technological limitations make this solution unfeasible.

Furthermore, placing the burden of absorbing the excess emissions on the South would perpetuate injustice. Conversely, granting the South the right to utilize its fair share of emissions would impede efforts to combat the climate crisis. Azad and Chakraborty [2023] contend that addressing these two issues is not mutually exclusive. One potential approach is for the North to provide financial support for emission reduction and carbon removal in the South, while concurrently striving for decarbonization in their own economy. As part of this process, nations that have surpassed their fair share of emissions would bear the costs of their own decarbonization as well as that of surplus

nations, primarily in the South, based on their current excess emissions and future emission reduction targets. Consequently, the concept of carbon indebtedness could be utilized as a critical factor in capturing the *responsibility* aspect of the UNFCCC's CBDR-RC approach.

Wealth and GDP: As we've previously discussed, the concept of capability is encompassed by the wealth and GDP of an economy. The former reflects the historical capability of these economies, while the latter represents the current capability of these countries to meet the transition needs of the global economy. The measurement of wealth can vary based on a range of methodologies and estimation techniques. The World Bank outlines that total wealth is determined by aggregating estimates of each component of wealth: produced capital, natural capital, human capital, and net foreign assets. The construction of the wealth accounts is guided by the concepts and methods of the System of National Accounts (SNA), a handbook developed by the UN Statistical Commission and utilized by virtually all countries in compiling their national income accounts.⁴ Gross Domestic Product (GDP) is a metric used to quantify the monetary value of final goods and services produced within a country's borders during a specific period, such as a quarter or a year. It represents the output generated within a country and encompasses products and services the final user purchases. Additionally, GDP also indicates a country's current economic capability to fund the climate finance.

Estimation Method: In determining the responsibility of transferring funds to the global South in terms of climate finance, we use all these three variables to create an average weighted index called the Payer Score Index (PSI). The PSI is calculated by taking the weighted average of the carbon debt, GDP, and wealth indices of various Annex-II countries. Equal weights are assigned to wealth and GDP to capture the capability aspect, and also, equal weights are assigned to the capability and responsibility aspects of the UNFCCC principle of CBDR-RC. The following steps outline the process of constructing the PSI and determining each Annex II country's share of the individual economy's payment responsibility.

First, we normalize each of the variables carbon debt, GDP and wealth of the Annex 2 countries using the simple normalization technique as shown in equation 1.

⁴For details on the methodology, please refer to the Wealth Accounts of the World Bank (<https://databank.worldbank.org/source/wealth-accounts>).

$$X \text{ normalized} = \frac{(X - X \text{ minimum})}{(X \text{ maximum} - X \text{ minimum})} \quad (1)$$

$$x_{norm} = \frac{x - x_{min}}{x_{max} - x_{min}}$$

Second, in equation 2, we define the Payer Score Index (PSI) for each of the Annex 2 countries based on the weightage schemes discussed above on these individual normalized variables.

$$\text{Payer Score Index (PSI)} = 0.5 *(\text{Carbon Debt Normalized (CDN)}) + 0.25 *(\text{Wealth Normalized (WN)}) + 0.25 *(\text{Gross Domestic Product Normalized (GDPN)}) \quad (2)$$

$$PSI = 0.5 *CDN + 0.25 *WN + 0.25 *GDPN$$

Third, we measure the absolute difference (Euclidean Distance) of each of these individual countries Payer Score Index (PSI) from the minimum PSI , i.e., the country that have the lowest level of PSI , would be least responsible for the payments of transfer of funds to the Global South. We then determine the share of individual economy's payment responsibility as the ratio of each economy's Euclidean Distance to the sum of the Euclidean Distance as shown in equation 3.

$$\text{Euclidean Distance } (ED_i) = |PSI_i - PSI_{minimum}|$$

$$\text{Share of i-th Annex II country's payment} = \frac{\text{Euclidean Distance of i-th country } (ED_i)}{\text{Sum of Euclidean Distances } (\sum_{i=1}^{24} ED_i)} \quad (3)$$

Finally, equation 4 gives the total payment of each country in the Annex II group, which is determined by their individual share times the total amount of the external funds needed from these advanced industrialized countries, as discussed in Section 2.2.2.

$$\text{Country's Total Payment} = \text{Share of each Country's Payment} * \text{Total External Contribution} \quad (4)$$

Data: Our analysis utilized secondary data from a study by Friedlingstein et al. [2023] to examine the carbon budget and carbon indebtedness in the global economy. Our focus was specifically on the countries in Annex II. We sourced wealth and gross domestic product data from the World Bank. In the next section, we report the results based on this methodology discussed.

4 Results

Figure 2 vividly illustrates the carbon debt of Annex II countries to the global economy. As of 2019, the United States holds the position of being the most carbon-indebted economy worldwide, with a staggering carbon debt of 445 $GTCO_2eq$. Germany follows closely at 87 $GTCO_2eq$, with the United Kingdom not far behind at 76 $GTCO_2eq$. This data serves as a stark reminder of the urgent need for these countries, particularly the United States, to assume a significant share of the responsibility in addressing climate change among the Annex II countries.

As previously discussed, capability is measured by wealth and GDP. Figure 3 displays the wealth distribution among the Annex II countries. The average wealth of the United States from 2014 to 2018 is approximately \$274.5 trillion, followed by Japan and Germany at \$69.6 trillion and \$53.7 trillion, respectively. In terms of historical capability, the USA has the highest capability among the Annex II countries to finance climate funds.

The gross domestic product (GDP) also presents a similar perspective as shown in Figure 4. The average GDP of the USA from 2017 to 2021, which encompasses the pandemic years of COVID-19, was \$21.2 trillion, followed by Japan and Germany at \$5.0 trillion and \$3.9 trillion, respectively. Therefore, even in terms of current capability, the top 3 countries - the USA, Japan, and Germany - should shoulder the maximum burden of distributing climate-related finance to the Global South.

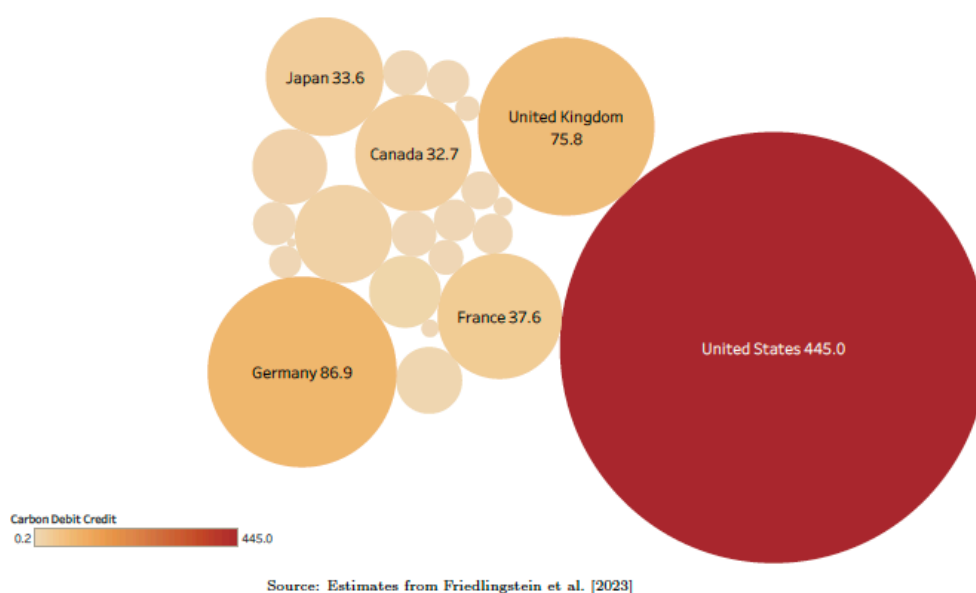
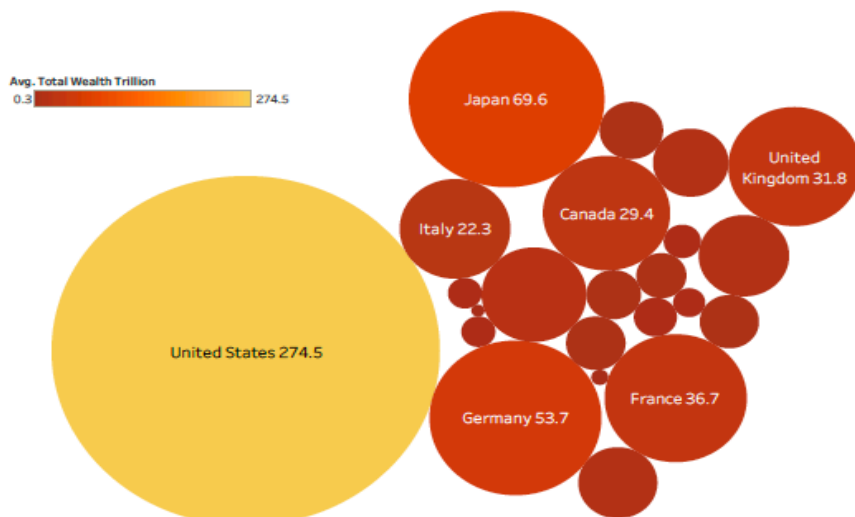
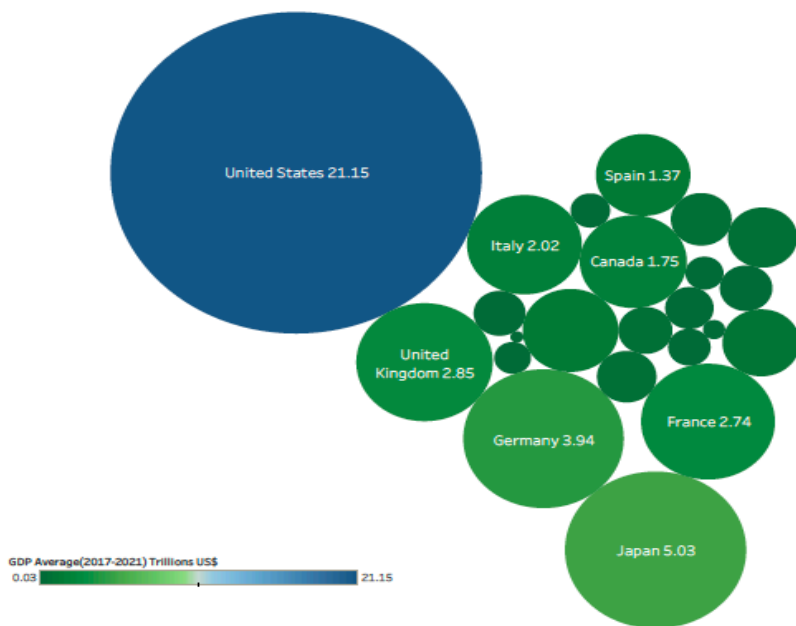


Figure 2: Carbon Debt of the Annex II Countries



Source: Wealth Accounts from the World Bank

Figure 3: Wealth of the Annex II Countries



Source: World Development Indicators, World Bank

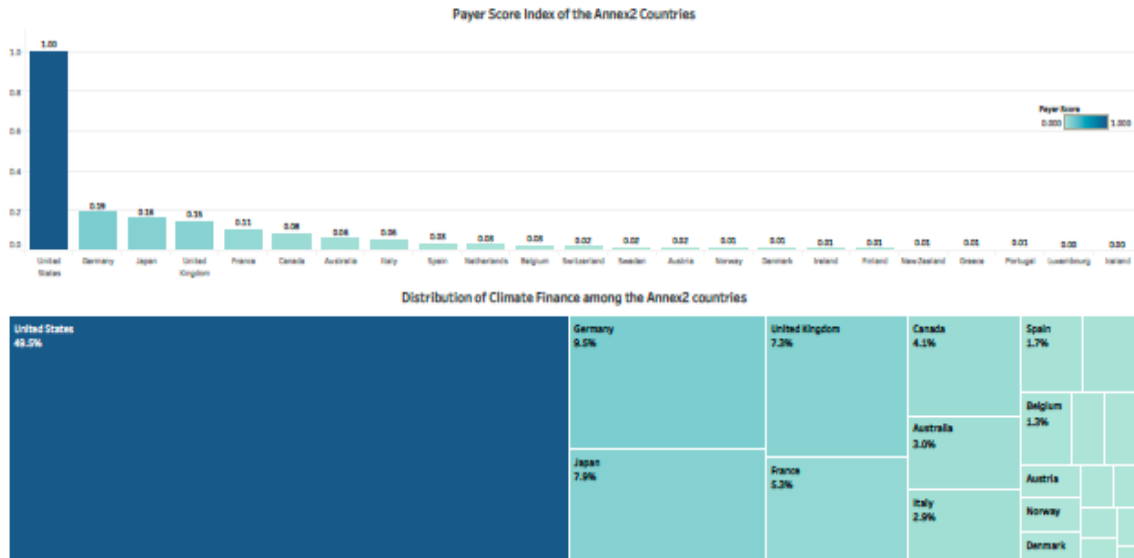
Figure 4: Gross Domestic Product of the Annex II Countries

By combining the responsibility and capability aspects, we have estimated the Payer Score Index (PSI) within the members of the Annex II countries. The top part of Figure 5 shows that the United States has the highest score of 1.00, indicating its leading position in terms of both responsibility and capability to finance climate funds for the South. Other Annex II countries such as Germany, Japan, and the United Kingdom have scores of 0.19, 0.16, and 0.15 respectively, showing their relatively lower but still significant levels of responsibility and capability. Based on these scores, the distribution of climate change-

related finance among the Annex II countries is determined. As depicted in Figure 5, the USA is expected to contribute almost half of the external funding of climate finance needed in the global South. Other G-7 countries like Germany, Japan, the United Kingdom, France, and Canada are expected to bear 9.5%, 7.9%, 7.3%, 5.3%, and 4.1% of the commitment, respectively.

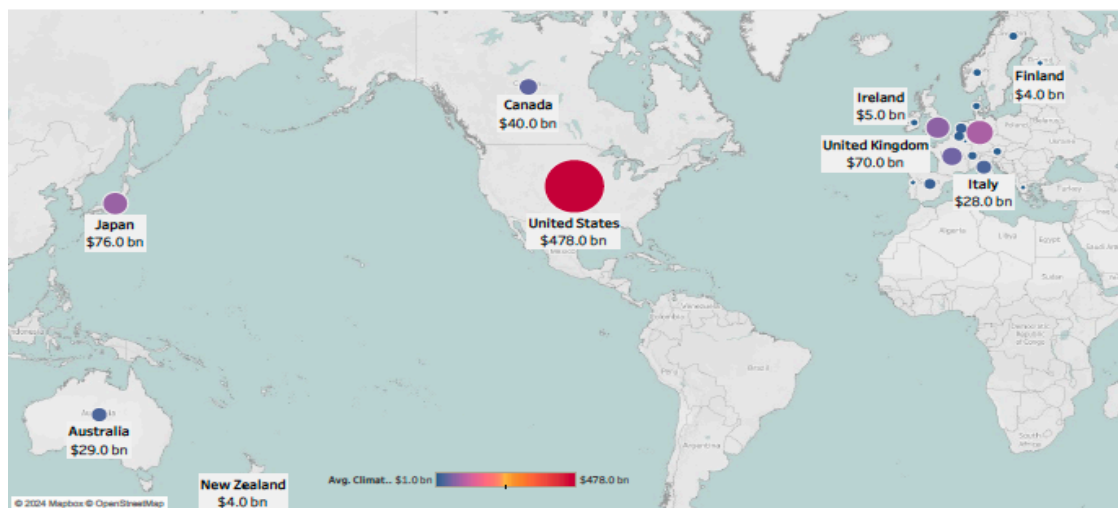
As previously emphasized, the total commitment of funds required from the Annex II member countries for the global South is approximately \$1.0 trillion annually. This is a collective responsibility that all member countries must bear. The United States, as a key player, is expected to contribute a significant portion, nearly \$500 billion annually, to meet its climate commitments and support the global South in this transition path. Similarly, other major economies, including Germany, Japan, the United Kingdom, France, and Canada, are also expected to make substantial annual contributions of \$95 billion, \$79 billion, \$73 billion, \$53 billion, and \$41 billion, respectively. This collective effort is crucial in addressing the global challenge of climate change. Figure 6 shows the annual total climate finance commitments of the various members of the Annex II countries.

The challenges of climate change and injustice are global and thus require a global solution. Azad and Chakraborty [2023] proposed the establishment of an International Carbon Fund (ICF), a new international body dedicated to overseeing the financial aspects of the global decarbonization process. The ICF should operate as a truly international entity, free from bias towards any particular country, and with the sole objective of ensuring a just and equitable transition to a decarbonized global economy. As suggested in this paper, funds mobilized from members of Annex II countries through this mechanism could be channeled to the ICF, which would then be responsible for allocating these resources to economies in the global South based on their specific needs. These needs could include investments in renewable energy infrastructure, adaptation measures, and capacity building for climate resilience. This cross-subsidization process must be managed by the ICF, which would maintain transparent financial records and ensure fair distribution. Given that these Annex II member countries will need to reduce their emissions significantly, they would be required to mobilize a higher share of climate finance to support their own transition and the transition of developing economies. How much of an additional burden does it add to these individual economies?



Source: Author's Calculations

Figure 5: Payer Score Index (PSI) & Share of Funds among the Annex II Countries



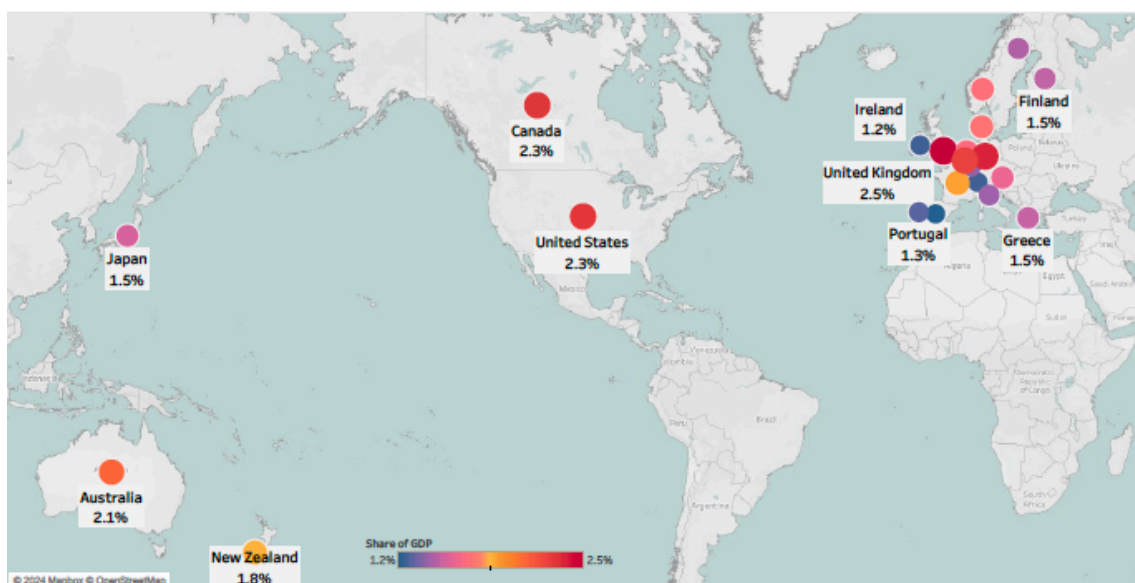
Source: Author's Calculations

Figure 6: Annual Climate Finance of Annex II Countries (in billions of US\$)

Figure 7 illustrates the distribution of the additional climate finance required for Annex II countries to support the climate risk-related needs of developing countries as a percentage of their GDP. Notably, the USA, which shoulders the largest share of commitments to the global South, would equate to 2.3% of its GDP. Other Annex II countries exhibit varying commitment levels, ranging from 1.2% for Ireland to 2.5% for the United Kingdom’s GDP. These countries may strongly oppose these additional commitments, citing concerns over the strain on their current economic resources. However, it is crucial to recognize that these commitments are not solely based on present circumstances but also reflect these economies’ historical responsibility towards the global

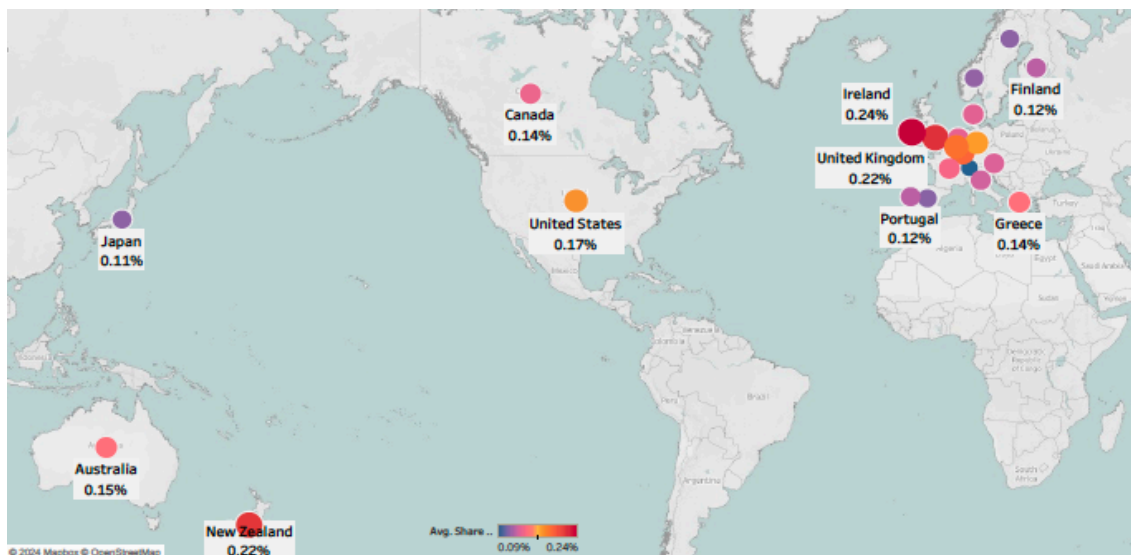
economy. Therefore, assessing these ratios in light of the historical wealth amassed by these economies rather than solely from the perspective of current income flows is imperative.

The data presented in Figure 8 illustrates the ratio of climate commitments of the Annex II member countries to the global South as a percentage of their economic wealth. When contextualized within the economic wealth of these nations, these commitments appear justifiable. Advanced economies have historically utilized carbon resources without cost, thereby accumulating substantial wealth within their economies, while also raising concerns of “impending damages to the global economy” due to potential economic losses and disruptions caused by climate change. Given this backdrop, the modest commitment ranging from 0.09% to 0.24% of their nation’s wealth to the Global South, which bears the brunt of climate change impacts despite contributing minimally to the crisis, appears reasonable on the international stage. Notably, the United States, responsible for nearly half of these total commitments to the Global South, as our estimates showed above, could mobilize these resources by imposing a nominal 0.17% tax on its economic wealth. It is important to emphasize that the intention is not to burden the impoverished working class, as these individuals typically lack substantial wealth, with the bottom 50% of households in the United States collectively holding only 2.5% of total household wealth [Kent and Ricketts, 2024]. Therefore, the focus is on taxing the affluent segment of the population, which largely shoulders the responsibility for this crisis, rather than penalizing the less privileged working class in Annex II member countries.



Source: Author's Calculations

Figure 7: Climate Finance Commitment to the Global South of Annex II Countries as a share of their GDP



Source: Author's Calculations

Figure 8: Climate Finance Commitment to the Global South of Annex II Countries as a share of their Wealth

5 Conclusion

It is imperative to recognize the looming threat of climate change, which poses a significant global challenge. Time is of the essence, and urgent and coordinated global action is required to address this crisis. Despite having contributed the least to the issue, developing countries are projected to bear the brunt of its impacts. The challenge for developing nations lies in finding a balance between mitigating the effects of climate change and acquiring the financial resources necessary to manage climate-related disasters, promote sustainable development, and safeguard their economies. This study delves into the climate finance needs of the Global South and explores how developed nations, particularly Annex II countries, can allocate funds to facilitate the mitigation and adaptation efforts of developing countries.

Estimates from reputable international organizations such as the International Energy Agency (IEA), International Renewable Energy Agency (IRENA), and Intergovernmental Panel on Climate Change (IPCC) suggest that the total global climate finance requirements in 2015 ranged from \$4.2 to \$5.7 trillion, with developing countries needing \$1.9 to \$2.0 trillion. Our own estimates, based on GDP, show that the annual climate finance needs of the world is around \$3.9 trillion, of which \$1.9 is needed by the developing ones. It is widely acknowledged that developing countries cannot meet these financial demands independently, and approximately \$1 trillion should be provided by Annex II countries to the former. Within the UNFCCC framework, the principle of common but differentiated

responsibilities and respective capabilities is recognized, and this principle could serve as a basis for Annex II nations to allocate funding to the Global South.

The proposed funding mechanism takes into consideration historical responsibility through carbon debt and assesses capability by factoring in wealth and gross domestic product equally. All Annex II countries carry a carbon debt to the world, signifying a substantial historical responsibility to the Global South. Our analysis measures capability by assigning equal weight to wealth and income, thus encompassing both historical responsibility and the current economic activity of these countries in funding climate finance. This approach ensures an equitable and fair distribution of the financial burden. Our analysis indicates that the United States of America is required to contribute nearly half of the total funds among the Annex II countries, with the remaining finance to be distributed among other Annex II nations. In terms of their GDP, Annex II countries are expected to allocate approximately 1.2-2.4%, while in terms of wealth, the allocation is only 0.09-0.24%. It is crucial to acknowledge the historical context of the climate crisis. Given the carbon legacy and the substantial carbon budget that developed countries have utilized to accumulate vast wealth in their economies, it is essential for them to allocate a small portion of this wealth to preserve humanity. The role of the Global South in addressing the climate crisis is invaluable, and the establishment of an International Carbon Fund, akin to other international bodies, can facilitate and oversee the process of transferring these funds and ensure their effective utilization by the Global South.

Bibliography

Natalia Alayza, Valerie Laxton, and Carolyn Neunuebel. Developing countries won't beat the climate crisis without tackling rising debt, September 2023. URL <https://www.wri.org/insights/debt-climate-action-developing-countries>.

Nadia Ameli, Olivier Dessens, Matthew Winning, Jennifer Cronin, Hugues Chenet, Paul Drummond, Alvaro Calzadilla, Gabriel Anandarajah, and Michael Grubb. Higher cost of finance exacerbates a climate investment trap in developing economies. *Nature Communications*, 12(1):1–12, 2021.

Rohit Azad and Shouvik Chakraborty. Z-factor of the climate crisis. *The Japanese Political Economy*, 49(2-3):274–294, 2023. doi: 10.1080/2329194X.2023.2270576. URL <https://doi.org/10.1080/2329194X.2023.2270576>.

Barbara Buchner, Baysa Naran, Rajashree Padmanabhi, Sean Stout, Costanza Strinati, Dharshan Wignarajah, Gaoyi Miao, Jake Connolly, and Nikita Marini. Global landscape of climate finance 2023. Technical report, Climate Policy Initiative, November 2023.

Tracy Carty, Jan Kowalzig, and Bertram Zagema. Climate finance shadow report 2020. Report, Oxfam, October 2020.

Meghan Daharwal, Hauke Engel, Sarah Frandsen, Kartik Jayaram, Adam Kendall, and Bob Mwaniki. Solving the climate finance equation for developing countries. Online Resource, December 2023. URL <https://www.mckinsey.com/capabilities/sustainability/our-insights/solving-the-climate-finance-equation-for-developing-countries>.

P. Friedlingstein, M. O'Sullivan, M. W. Jones, R. M. Andrew, D. C. E. Bakker, J. Hauck, P. Landschützer, C. Le Quééré, I. T. Lujckx, G. P. Peters, W. Peters, J. Pongratz, C. Schwingshackl, S. Sitch, J. G. Canadell, P. Ciais, R. B. Jackson, S. R. Alin, P. Anthoni, L. Barbero, N. R. Bates, M. Becker, N. Bellouin, B. Decharme, L. Bopp, I. B. M. Brasika, P. Cadule, M. A. Chamberlain, N. Chandra, T.-T.-T. Chau, F. Chevallier, L. P. Chini, M. Cronin, X. Dou, K. Enyo, W. Evans, S. Falk, R. A. Feely, L. Feng, D. J. Ford, T. Gasser, J. Ghattas, T. Gkritzalis, G. Grassi, L. Gregor, N. Gruber, Ö. Gürses, I. Harris, M. Hefner, J. Heinke, R. A. Houghton, G. C. Hurtt, Y. Iida, T. Ilyina, A. R. Jacobson, A. Jain, T. Jarníková, A. Jersild, F. Jiang, Z. Jin, F. Joos, E. Kato, R. F. Keeling, D. Kennedy, K. Klein Goldewijk, J. Knauer, J. I. Korsbakken, A. Körtzinger, X. Lan, N. Lefèvre, H. Li, J. Liu, Z. Liu, L. Ma, G. Marland, N. Mayot, P. C. McGuire, G. A. McKinley, G. Meyer, E. J. Morgan, D. R. Munro, S.-I. Nakaoka, Y. Niwa, K. M. O'Brien, A. Olsen, A. M. Omar, T. Ono, M. Paulsen, D. Pierrot, K. Pockock, B. Poulter, C. M. Powis, G. Rehder, L. Resplandy, E. Robertson, C. Rödenbeck, T. M. Rosan, J. Schwinger, R. Séférian, T. L. Smallman, S. M. Smith, R. Sospedra-Alfonso, Q. Sun, A. J. Sutton, C. Sweeney, S. Takao, P. P. Tans, H. Tian, B. Tilbrook, H. Tsujino, F. Tubiello, G. R. van der Werf, E. van Ooijen, R. Wanninkhof, M. Watanabe, C. Wimart-Rousseau, D. Yang, X. Yang, W. Yuan, X. Yue, S. Zaehle,

J. Zeng, and B. Zheng. Global carbon budget 2023. *Earth Syst. Sci. Data*, 15:5301–5369, 2023. doi: <https://doi.org/10.5194/essd-15-5301-2023,2023>.

Gaurav Ganti, Matthew J Gidden, Christopher J Smith, Claire Fyson, Alexander Nauels, Keywan Riahi, and Carl-Friedrich Schleußner. Uncompensated claims to fair emission space risk putting paris agreement goals out of reach. *Environmental research Letters*, 18(2), February 2023.

IEA. Net zero by 2050. Technical report, IEA, Paris, 2021. URL <https://www.iea.org/reports/net-zero-by-2050>.

IPCC. Full Report. In V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekci, R. Yu, and B. Zhou, editors, *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press (in press), <https://www.ipcc.ch/report/ar6/wg1/>, 2021.

IRENA. World energy transitions outlook 2023: 1.5°C pathway. Technical report, International Renewable Energy Agency, Abu Dhabi, 2023.

T Jayaraman and Tejal Kanitkar. The Paris Agreement: Deepening the climate crisis. *Economic and Political Weekly*, 51(3):10–13, 2016. ISSN 00129976, 23498846. URL <http://www.jstor.org/stable/44004194>.

Dipak Dasgupta Jean-Charles Hourcade and Frédéric Gherzi. Accelerating the speed and scale of climate finance in the post-pandemic context. *Climate Policy*, 21(10): 1383–1397, 2021. doi: 10.1080/14693062.2021.1977599.

Tejal Kanitkar, T Jayaraman, Mario D’Souza, Mukul Sanwal, Prabir Purkayastha, Rajbans Talwar, and D Raghunandan. Meeting equity in a finite carbon world. *Proceedings of Global Carbon Budgets and Burden Sharing in Mitigation Actions*, 2010.

Ana Hernández Kent and Lowell R. Ricketts. The state of US wealth inequality. Federal Reserve Bank of St. Louis, May 2024. URL <https://www.stlouisfed.org/institute-for-economic-equity/the-state-of-us-wealth-inequality#:~:text=How%20much%20wealth%20inequality%20is,wealth%20had%20%2450%2C000%20on%20average.>

Mizan Khan, Stacy-ann Robinson, Romain Weikmans, David Ciplet, and J. Timmons Roberts. Twenty-five years of adaptation finance through a climate justice lens. *Climatic Change*, 161(2):251–269, 2020. doi: 10.1007/s10584-019-02563-x. URL <https://doi.org/10.1007/s10584-019-02563-x>.

Maria Kozloski, Veronica Chau, Lily Han, Naomi Desai, Yvonne Yau, Qahir Dhanani, Claudia Newman-Martin, Alex Bashian, Wendy Woods, and Vinay Shandal. What gets measured gets financed. Technical report, The Rockefeller Foundation & Boston Consulting Group, November 2022.

V. MassonDelmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekci, R. Yu, and B. Zhou, editors. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, chapter IPCC, 2021: Summary for Policymakers. Cambridge University Press, 2021.

OECD. *Climate Finance Provided and Mobilised by Developed Countries in 2013-2021*. OECD Publishing, 2023. doi: <https://doi.org/https://doi.org/10.1787/e20d2bc7-en>. URL <https://www.oecd-ilibrary.org/content/publication/e20d2bc7-en>.

J Timmons Roberts and Bradley Parks. *A climate of injustice: Global inequality, north-south politics, and climate policy*. MIT press, 2006.

Vera Songwe, Nicholas Stern, and Amar Bhattacharya. Finance for climate action: scaling up investment for climate and development. Technical report, Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, London, November 2022.

David I. Stern. *Energy and economic growth*, pages 28–46. Routledge, 1st edition, 2019.

Jocelyn Timperley. The broken \$ 100-billion promise of climate finance — and how to fix it. *Nature*, 598:400–402, 2021. doi: <https://doi.org/10.1038/d41586-021-02846-3>.

United Nations Environment Programme. *Adaptation gap report 2023: Underfinanced, Underprepared, inadequate investment and planning on climate adaptation leaves world exposed*. Technical report, UNEP and WASP, Nairobi, 2023.

United Nations Framework Convention on Climate Change (UNFCCC). 2018 biennial assessment and overview of climate finance flows technical report. UN standing committee on finance. Technical report, UNFCCC, Bonn, Germany, 2018.

Tian WANG and Xiang GAO. Reflection and operationalization of the common but differentiated responsibilities and respective capabilities principle in the transparency framework under the international climate change regime. *Advances in Climate Change Research*, 9(4):253–263, 2018. ISSN 1674-9278. doi: <https://doi.org/10.1016/j.accre.2018.12.004>. URL <https://www.sciencedirect.com/science/article/pii/S1674927818301230>.

Farhana Yamin and Joanna Depledge. *The international climate change regime: a guide to rules, institutions and procedures*. Cambridge University Press, 2004.