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Stable Investments in Times of Instability: Bridging Interests to Revive International Climate Diplomacy

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Key Messages

Global warming poses major threats to societal stability and economic prosperity. Human-induced climate change is intensifying globally, with record heatwaves, floods, and wildfires affecting billions of people and economies worldwide. These impacts are uneven across regions and populations, hitting vulnerable communities hardest. Global temperatures are projected to temporarily exceed 1.5°C within the next few years, highlighting the urgent need for strengthened commitments at COP30 and making coordinated emission reductions and large-scale carbon dioxide removal (CDR) essential components of economic risk management.

Cutting emissions is not only an environmental and moral imperative but also an economic necessity. It limits the rising costs of climate damages, creates growth opportunities through green innovation and emerging markets, and enhances energy sovereignty and economic security by reducing dependence on fossil fuels. These rationales underscore the importance of carefully designed incentive mechanisms that support resilient international cooperation and enable durable, high-impact climate investments even amid geopolitical fragmentation and political backlash against climate policy.

Climate investments have reached a record high – but will need to keep rising. In 2024, annual global investments in clean energy technologies and infrastructure amounted to USD 2 trillion. To stay on track for net zero targets, this figure would need to roughly triple, with even steeper growth required in low- and middle-income countries. As greenhouse gas emissions are rising most rapidly in these countries, scaling up green investments there is essential. Their comparatively low marginal abatement costs represent a key lever for achieving efficient mitigation.

Geoeconomic fragmentation and diverse national interests call for carefully designed incentive mechanisms to unlock climate investments. Countries vary in their capacity to engage in green markets, their dependence on carbon-intensive sectors, and in their ability to deploy low-carbon technologies. Aligning national interests will be critical to mobilizing the capital needed for the green transition – even as geopolitical divides widen and domestic politics complicate international climate cooperation.

Carbon Border Adjustment Mechanisms can help foster climate alliances through reciprocity. The EU's Carbon Border Adjustment Mechanism (CBAM) serves a dual purpose. First, it aims to level the competitive playing field for industries by addressing carbon leakage. Second, it incentivizes trade partners to implement carbon pricing, thereby fostering a de facto climate coalition that can reduce free-riding on international climate action and significantly amplify global emissions reductions – far beyond what unilateral EU emission cuts could achieve.

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Fossil-fuel importers can scale climate action by establishing performance-based jurisdictional reward funds. It is in the self-interest of major fuel-importing economies, such as the EU and China, to finance reductions in the demand for fossil fuels at home and abroad. Jointly funding reductions of fossil fuel consumption in low- and middle-income countries through performance-based jurisdictional reward funds, can enhance the effectiveness of international climate transfers. Benefits for the funding countries arise through two channels: First, lowering emissions reduces climate damages, a substantial share of which accrues to large economies. Second, the resulting decrease in fossil fuel demand creates a terms-of-trade benefit for net importing countries through lower fuel prices. The mechanism leverages lower mitigation costs in low- and middle-income countries, generating efficiency gains. By conditioning rewards on achieving a pre-defined performance level, the mechanism also ensures that climate action is effectively strengthened.

Decisive action is needed now – especially since climate policy faces growing contestation in many countries. Despite the commitments to the targets of the Paris Agreement, global emissions continue to rise, and climate finance remains insufficient. Creating effective incentives for both public and private stakeholders is crucial to accelerate the mobilization of funds for climate action – not only to achieve the objectives of the Baku Declaration adopted at last year's UN Climate Conference, but also as a fundamental prerequisite for security and economic prosperity.

1. Economic rationales for climate investments

1.1 Persistent warming, temperature overshoot, and risk management

In 2025, the impacts of human-induced climate change continue to intensify across the globe. Record-breaking heat, widespread wildfires and devastating floods are making the consequences of climate change increasingly evident. Already in mid-April 2025, parts of India and Pakistan were struck by extreme heat, with maximum temperatures rising above 40°C and in some locations even as high as 49°C (NCEI/NOAA, 2025a). In July 2025, heatwaves affected Europe, notably Sweden and Finland, which endured prolonged periods above 30°C. In Iran and Iraq, temperatures locally exceeded 50°C in August, disrupting electricity and water supplies, education, and labor (WMO, 2025a). Meanwhile, Canada has experienced one of its worst wildfire seasons on record. In the US, California saw catastrophic fire events in the beginning of the year, while other regions encountered unusually humid conditions, resulting in severe flash floods (CIRA, 2025; NCEI/NOAA, 2025b).

Climate change can cause economic losses through multiple channels. The projected impacts of climate change on health, for instance, will impose significant costs on lower- middle-income countries (World Bank, 2024). High-income countries that participate in international trade and rely on integrated supply chains also face high economic costs of carbon emissions in absolute terms. The smoke of wildfires in the US has partly nullified improvements in local air pollution from the last decades. Additional deaths from wildfire-induced local air pollution are expected to amount to 71,000 by 2050 in the US (Qiu et al., 2025).

While climate damages affect all regions in the world, the impacts of climate change and the associated vulnerabilities vary significantly across countries. Low-income nations are generally more exposed to climate-related disasters and possess limited adaptive capacities, resulting in a disproportionately high burden of physical climate damage despite their relatively low absolute emission levels (World Economic Forum, 2023). This imbalance can also be observed within countries: while individuals with higher incomes contribute more to global emissions, the adverse effects of climate change are felt most acutely by poorer segments of the population (Gilli et al., 2024).

Recent climate extremes are not isolated anomalies – they reflect a persistent warming trend. Every year from 2015 to 2024 ranks among the ten warmest on record (WMO, 2025b), and averaged data indicate that global surface temperature in 2024 reached 1.55°C above the 1850-1900 baseline (Tollefson, 2025). While a single year exceeding 1.5°C does not imply that the Paris Agreement's long-term temperature goal has been permanently surpassed, it signals that the world is on an almost inevitable trajectory to (at least temporarily) exceed it (Bevacqua et al., 2025; IPCC, 2021).

At current emission levels, the remaining carbon budget consistent with limiting warming to 1.5°C will be exhausted in less than four years (Forster et al., 2025). Although progress has been made since the adoption of the Paris Agreement in 2015, current emission trajectories fall short of its objectives. Even full implementation of the updated 2035 Nationally Determined Contributions (NDCs) would still result in 2.3–2.5°C of warming by 2100 (UNEP, 2025), compared with 2.6–2.8°C under the previous NDCs (UNEP, 2024). While countries are bound to present strengthened national climate plans at COP30 (ICJ, 2025), the key question today is not whether 1.5°C will be exceeded, but rather by how much and for how long (Peters, 2024; Reisinger et al., 2025).

Climate-related risks rise substantially if global warming exceeds 1.5°C compared with pathways that remain below this threshold. The magnitude and duration of the overshoot will determine the severity of resulting hazards and the complexity of managing them (IPCC, 2022). Limiting warming requires coordinated international efforts to deliver deep, sustained emission reductions alongside large-scale carbon dioxide removal (CDR), enabling net-zero emissions. Returning global warming to 1.5°C would further require net-negative emissions, removing accumulated CO_2 and "cleaning up" the atmosphere (Edenhofer et al., 2024; Edenhofer et al., 2025a). This outlines a clear guiding principle for 21st-century climate policy: "slow down warming, stop warming, bring warming down" (ESABCC, 2025).

With climate uncertainties mounting and the carbon budget approaching exhaustion, effective climate action has become a central pillar of economic risk management. The physical impacts of climate change translate directly into economic costs – from declining agricultural yields and strained water resources to impaired health and reduced labor productivity (IPCC, 2022). These economic implications are both immediate and long-term, affecting growth prospects, fiscal stability and political resilience across regions (e.g. Burke et al., 2015; IMF 2025; Salmon-Genel, 2025). Recognizing climate change as an economic risk underscores the importance of proactive measures: addressing it is not only an environmental or moral imperative, but also a safeguard for sustained prosperity. The following section outlines three core dimensions through which actions generate measurable returns: lowering economic damages, creating new growth opportunities and mitigating security risks.

1.2 Three dimensions of the economic rationale for climate investments

First, avoiding climate damages generates clear economic benefits, as rising temperatures impose costs that threaten to erode prosperity and stability. Howard/Sterner (2025) conduct a meta-analysis of climate damage estimates and find that non-catastrophic damages for a 3°C warming range from 3.2% to 9.2% of global GDP, depending on whether growth effects are included. When catastrophic impacts – defined as large, abrupt, and often irreversible changes in the climate system – are taken into account, the range increases to 12.5–18.5% of GDP, reflecting differences in how such damages are defined, from narrow tipping-point events to broader interpretations. What is more, these impacts affect regions, sectors, and populations in highly unequal ways. Rising weather and climate extremes already expose billions of people to acute risks today, with the most severe consequences falling on the least developed countries and low-income households (IPCC, 2023).

Market-based climate damages are commonly expressed as the Social Cost of Carbon (SCC). The SCC quantifies the monetized damages resulting from an additional ton of CO_2, integrating multiple impact channels such as changes in agricultural productivity, human health or energy consumption patterns. However, most SCC calculations omit non-market impacts like biodiversity loss, geopolitical conflicts as well as the profound and self-enforcing risks associated with crossing Earth system tipping points. Excluding these complex and hard-to-quantify effects likely leads to an underestimation of the true SCC. Tol (2023) documents a systematic upward trend in estimates of the SCC across the literature – primarily because newer studies apply lower discount rates and reflect improvements in overall research quality. The U.S. Environmental Protection Agency (EPA) estimates the SCC for 2020 at USD 120-340/tCO_2, with a central estimate of USD 190/tCO_2 at a 2% discount rate. By mid-century, these figures rise to USD 200–480 per ton (EPA, 2023).[5] These figures broadly align with Rennert et al. (2022), who report a value of USD 185/tCO_2 and with recent literature converging around a mean SCC of USD 283/tCO_2 in 2020 (Moore et al., 2024). Newer models that analyze compound global temperature shocks that affect all countries simultaneously, rather than aggregating country-level data, indicate even higher values, exceeding USD 1,000/tCO_2 (Bilal/Känzig, 2025b).

SCC estimates have become central to shaping climate policy, providing a benchmark for evaluating the costs and benefits of climate action. When SCC values are incorporated into regulatory analyses, investments that might otherwise appear prohibitively expensive can be recognized as cost-effective. This integration fundamentally corrects the decision-making perspective by accounting for the returns of climate action. Comparing domestic costs and benefits of decarbonization reveals that in major economies, comprehensive unilateral decarbonization might even "pay for itself" (Bilal/Känzig 2025b).

Second, developing the green economy can unlock new market segments, extending the rationale for climate investments beyond avoided damages to include opportunities for growth and innovation. Green innovation is central to accelerating climate action and decarbonizing the economy (IPCC, 2023). While climate policy reshapes production processes and imposes (uneven) adjustment costs on carbon-dependent sectors

[5] For 2025, the US EPA estimates the SCC at USD 212/tCO_2 (USD 2020) using a 2% discount rate.

(Claeys et al., 2024; Känzig, 2025; Pisani-Ferry, 2021), targeted support for research and innovation can accelerate the deployment of low-carbon alternatives and help cushion transition costs (Acemoglu et al., 2012; Hasna et al., 2023). This entails not only large-scale deployment of solar panels, wind farms, green hydrogen production, transport infrastructure and advanced batteries, but also system-level transformations complemented by carbon capture and storage for hard-to-abate activities. Achieving net-zero targets depends both on scaling existing clean technologies and on fostering innovation that delivers breakthroughs where solutions remain scarce (IEA, 2021a; Paunov et al., 2025).

Rapid growth in green sectors creates major opportunities for production and export. Both the demand for green technologies and capital inflows into these sectors have risen sharply in recent years, averaging at 7.3% and 9.6% per year, respectively (Kohn et al., 2025). Six markets for key mass-produced clean energy technologies – solar PV, wind, electric vehicles, batteries, electrolyzers, and heat pumps – are expanding even more dynamically. Between 2015 and 2023, these markets have grown almost fourfold, reaching a total value of over USD 700 billion, and, under current policies, are projected to almost triple again by 2035 (IEA, 2024). At the company level, producing and deploying green technologies can improve access to finance and strengthen competitiveness, particularly in times of disruption (Kohn et al., 2025).

Third, climate investments can enhance resilience by reducing the economic dependence on fossil fuels. Fossil fuel importers can strengthen their energy sovereignty and reduce exposure to volatile global markets by lowering their dependence on foreign suppliers. The Russian war in Ukraine illustrates these benefits: cutting imports limits the geopolitical leverage of Russia as a large exporter and constrains its capacity to finance military aggression (Beaufils et al., 2025). At the same time, declining global fuel demand improves importers' terms-of-trade, yielding economic gains and creating new incentives for coordinated international climate action and investment. These dynamics may lay the foundation for mutually beneficial cooperation across world regions (cf. section 3). However, bridging tensions between states and reconciling diverging interests is crucial, because cutting the demand for fossil fuels faces resistance from fossil fuel exporters. For these countries, declining global demand creates major fiscal and structural challenges (IPCC, 2023). Economic instability is particularly likely in economies with limited capacity to diversify their export base, develop alternative growth engines, or manage compounding climate impacts (Mesa Puyo et al., 2024; Thielges, 2023). As a result, climate investments that are beneficial at the aggregate level are often contested by incumbent actors. The following section outlines country-specific barriers to green investments that need to be overcome to achieve the required cuts in global emissions.

2. The twin challenges of climate finance and decarbonization

2.1 Scaling climate investments

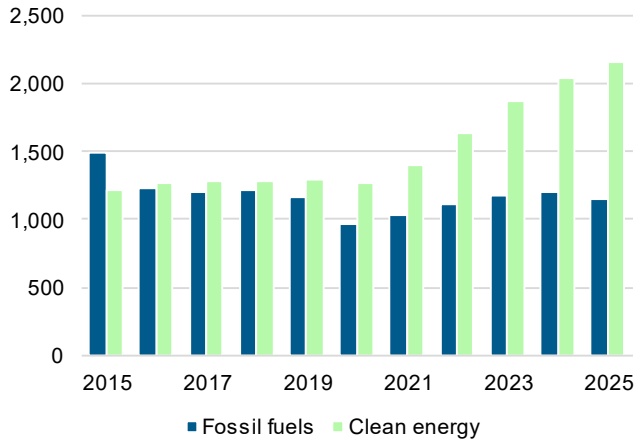
The recent surge in climate investments must continue if net zero targets are to be met. In 2024, global investments in clean energy reached around USD 2 trillion – roughly twice the amount directed toward fossil energy (chart 1). This momentum must be sustained and even expanded: global investment requirements consistent with net zero scenarios are estimated to be about three times higher, averaging at around USD 6 trillion per year until 2050, with estimates ranging between USD 3 and 8 trillion (Naran et al., 2025, IRENA, 2024; Bhattacharya et al., 2024). While this level could be reached in 2036 if investments were to grow at the pace observed between 2019 and 2024, an investment gap of USD 26 trillion would have accumulated by that time. This gap would need to be closed through even higher investment growth in the following years. Yet, rising global fragmentation and conflict pose challenges to further increases in investment (Block et al., 2025).

The largest growth in investments is needed in the Global South, where access to private capital is limited. Current investment levels in these countries are low, and achieving net zero emission goals requires a rapid expansion: current investment flows would have to increase by up to a factor of nine (chart 2). At the same time, these regions rely heavily on foreign funds: in 2023, only 23–61% of total climate finance in countries of the Global South was domestically sourced, compared with 80% in Western Europe and 88% in the US and Canada. Private investment is similarly constrained in the Global South, accounting for 30–66% of total financing, versus 73% and 91% in Western Europe and the US and Canada, respectively. Closing the gaps is essential both to prevent the disproportionate costs of inaction (World Bank, 2024) and to stimulate economic growth through climate solutions.

Europe is currently the main provider of public climate finance to developing countries. In 2024, the EU and its member states contributed EUR 31.7 billion from public sources and mobilized an additional EUR 11 billion in private finance to support developing countries in addressing climate change (European Council, 2025). Considering total global climate funding – including both domestic and international finance flows – Europe and

China are the leading investors. Between 2018 and 2023, China mobilized 35% of all global climate finance, followed by Western Europe (27%) and the US and Canada (together 14%) (Naran et al., 2025).[6]

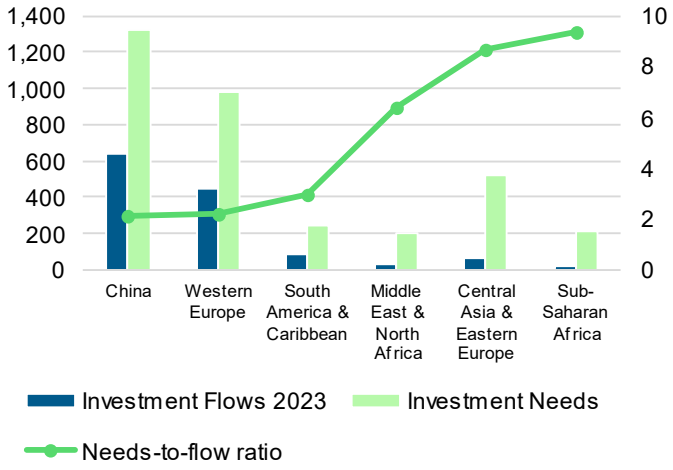
Chart 1: Global fossil vs. clean investment flows (in billion USD)



Note: Clean energy investments refer to renewables, nuclear, grids and storage, energy efficiency and end use electrification; historical data for the years 2015-2024 and estimates for 2025.

Sources: IEA (2025)

Chart 2: Mitigation investment needs vs. flows in selected regions (in billion USD, ratio)



Note: Mitigation investments refer to energy systems, transport, building and infrastructure, and agriculture, forestry and other land use; needs-to-flow ratio is investment needs divided by current flows.

Sources: Naran et al. (2025)

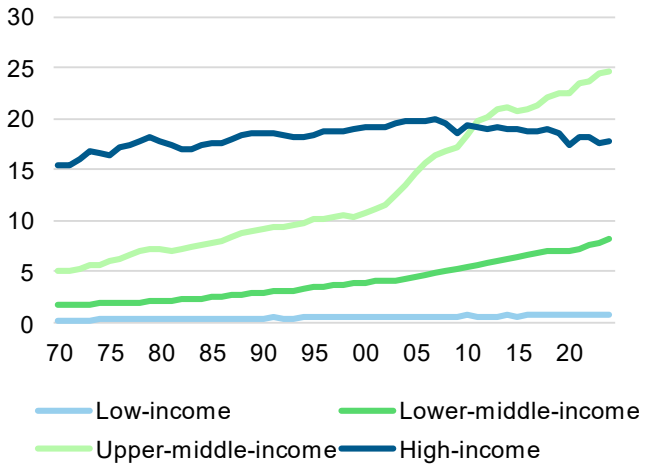
2.2 Shifting emissions dynamics amid heterogeneous challenges

While climate investments have yet to catch up with the scale of global needs, the landscape of carbon emitters is shifting. Industrialized countries account for the largest share of cumulative greenhouse gas emissions released to date. Today, however, the share of global emissions from low- and middle-income countries is rising and even exceeds their share in global economic output at purchasing power parity. In 2011, upper-middle-income countries alone surpassed the aggregate greenhouse gas emissions of high-income countries for the first time (see chart 3). Since then, their contribution has risen continuously and is projected to continue increasing in the near to medium term (IEA, 2021b). Lower-middle-income countries are also driving a growing share of global emissions (see chart 4). Between 2021 and 2024, greenhouse gas emissions in these countries increased at a compound annual growth rate of 3.9%, compared with 1.6% in upper-middle-income countries and 1.3% globally. Even low-income countries displayed emissions growth averaging at 1.9%, albeit from very low levels – and their contribution to overall emissions growth remains negligible.

Reconciling economic growth and environmental sustainability can be challenging for developing and emerging economies. Middle-income countries, in particular, often start out with relatively high carbon intensity of GDP, facing a difficult balancing act. They aim to catch up economically and pursue development goals while simultaneously addressing the growing need to shift their capital stock away from fossil fuels. For these countries, access to foreign capital is crucial for adopting green technologies (Fornaro et al., 2025). However, limited access to affordable long-term capital, underdeveloped financial markets, and high perceived investment risks often constrain both private and public international investment. In the case of climate investments, complex risk profiles, large investment volumes, long time horizons, and gaps in knowledge and capacity represent additional barriers (Benayad et al., 2023).

[6] Note: While China has emerged as a major provider of climate-related investments in third countries (Cichocka/Mitchell, 2024), it is officially classified as a non-Annex country under the United Nations Framework Convention on Climate Change (UNFCCC). Citing this status, China maintains that all of its contributions to climate finance are therefore voluntary.

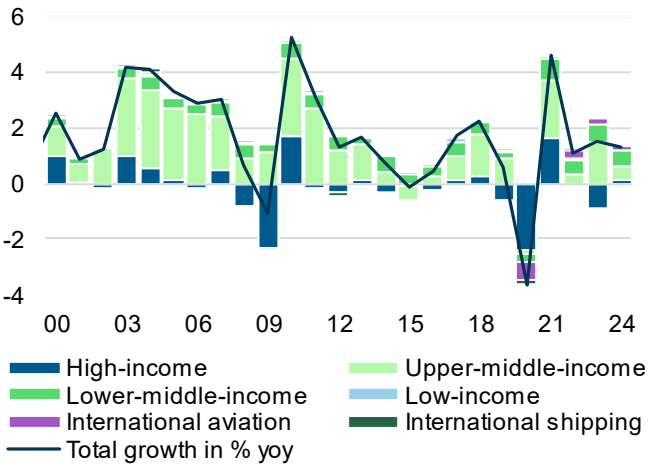
Chart 3: Greenhouse gas emissions by country-level income groups (in Gt. CO_2-eq.)



Note: based on 2025 income classifications.

Sources: KfW Research based on EDGAR (Emissions Database for Global Atmospheric Research) 2025, World Bank

Chart 4: Annual contribution to global greenhouse gas emissions growth (in Ppt. vs. previous year)



Note: based on 2025 income classifications.

Sources: KfW Research based on EDGAR (Emissions Database for Global Atmospheric Research) 2025, World Bank

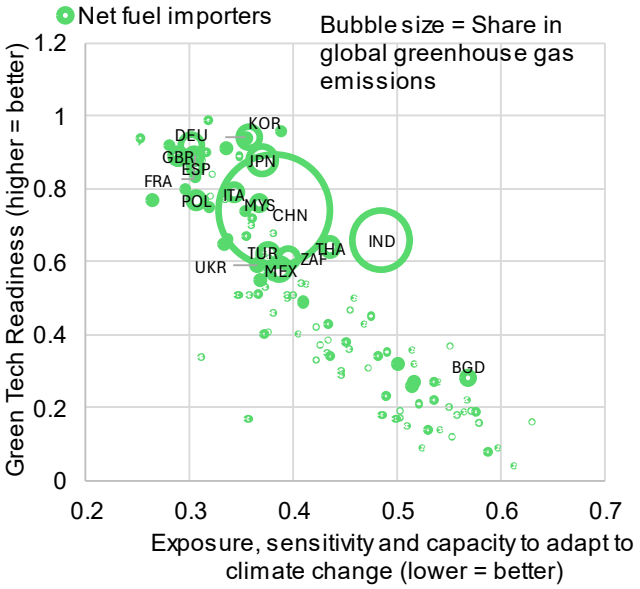
Efficient climate policies are a key driver of decarbonization in the Global South, but significant obstacles remain. In 2024, developing countries accounted for approximately 60% of new sustainable finance policy measures, including the introduction of carbon pricing frameworks (UNCTAD, 2025). When implemented with sufficient ambition, revenue mobilization from carbon pricing can yield substantial benefits – especially in contexts of already strained public finances and, in some cases, unsustainable debt trajectories. Globally, carbon pricing revenues amounted to over USD 100 billion in 2024. However, this is still only a small fraction of the USD 620 billion spent on fossil fuel subsidies in 2023 (World Bank, 2025). Carbon pricing revenues may not only be used to finance green projects but also broader development needs and social compensation schemes. Yet, a careful policy design is crucial to achieving both national developmental and environmental objectives. Similarly, reforming fossil fuel subsidies remains a complex but important task. While often hindered by political and implementation challenges, phasing-out these subsidies can help correct energy price distortions, improve the competitiveness of clean technologies, and prevent the lock-in of carbon-intensive infrastructure (IEA, 2025; IMF, n.d.).

The green economy presents both opportunities and challenges for low and middle-income countries. While the vision of a green economy may be appealing, many approaches of decarbonization require the industrial capacity, human capital, and fiscal resources generally associated with high-income countries (Barbier, 2016). Therefore, challenges arise for credible green economy promises in the Global South, implying trade-offs between sustainability goals and social inclusiveness (Hochstetler, 2025). These challenges and opportunities are particularly evident in the material realities of the green economy: on the one hand, many green products will boost the demand for critical minerals, intensifying the environmental and social pressures associated with resource extraction in the Global South. On the other hand, producing green intermediates and relocating parts of energy-intensive value chains to the Global South can create opportunities to diversify local economies, increase domestic value addition, and provide critical inputs that strengthen the competitiveness of industries in advanced economies (McWilliams et al., 2025; Verpoort et al., 2024).

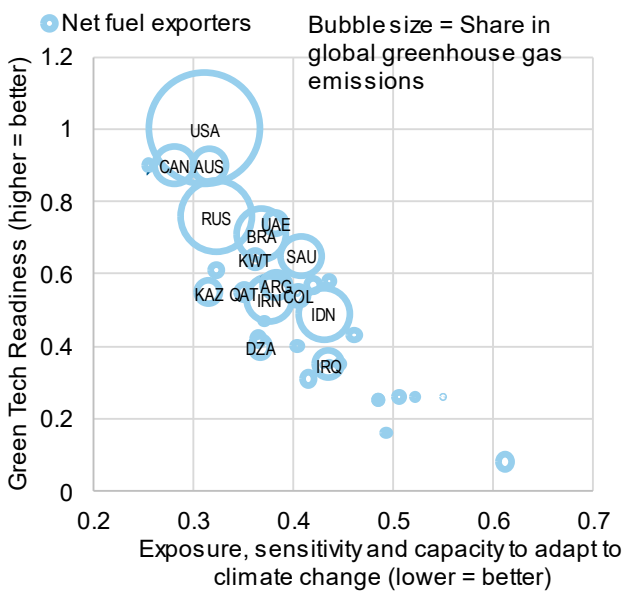
Participation in green markets is closely linked to a country's income level. According to UNCTAD's Green Tech Readiness Score, the ability to adopt and deploy green technologies remains largely confined to high-income countries as well as a few upper middle-income countries (chart 5). Conversely, those most vulnerable to the effects of climate change are often not equipped to deploy innovative technologies. However, a middle ground exists – comprising both fuel importers and exporters – where incentives to reduce domestic climate-related impacts align with a growing ability to participate in green markets.

Chart 5: Green Tech Readiness and Vulnerability to Climate Change
(Indices)

a) Net fuel importers



b) Net fuel exporters



Notes: Country codes are displayed for economies with a share in global greenhouse gas emissions 2024 above 0.3%, subject to data availability. Fuel imports and exports refer to Harmonized System Code 27: mineral fuels, mineral oils, and products of their distillation; bituminous substances; mineral waxes.

Sources: KfW Research based on EDGAR (Emissions Database for Global Atmospheric Research) 2025, World Bank, University of Notre Dame Global Adaptation Initiative, UNCTAD, ITC Trade Map, IMF World Economic Outlook 2025.

2.3 Political frictions and new routes for cooperation

While international cooperation is urgently needed, it is becoming increasingly difficult due to geoeconomic fragmentation. Rising protectionism, geopolitical tensions and shifts in political preferences towards 'my country first'-policies risk nations' backtracking from previous – albeit insufficient – progress in strengthening climate policies. Major setbacks or prolonged periods of inaction caused by diluted agendas risk accelerating global warming beyond critical thresholds. These trends undermine the coordination of emission reduction efforts across countries and jeopardize the stability of global alliances, intensifying the collective action dilemma at the heart of climate protection.

Non-cooperation from large economies has particularly damaging consequences for climate finance, as it opens funding gaps for developing countries and weakens the credibility of global governance. It is crucial to avoid an undesirable equilibrium, in which advanced economies weaken their commitments to provide financial transfers, while developing and emerging economies scale down or refrain from making decarbonization commitments.

While current shifts are challenging, a multipolar world also opens up opportunities for the formation of new coalitions. From the perspective of climate finance providers, a key incentive arises from cross-country differences in the costs of achieving climate-beneficial outcomes. Since marginal costs of mitigating the impacts of climate change are unevenly distributed across countries, climate policy can be achieved at different total costs. Generally, marginal abatement costs are lower in low- and middle-income countries (Greiff/Kempa, 2025; Aldy et al., 2016). Providing financial transfers that enable these countries to contribute more to global emission reductions therefore generates cost-effective benefits. Forming coalitions that align climate action with self-interest is key to global progress.

Building on this rationale, there is a strong economic case for financing climate action abroad. For high-income countries, international climate investments not only reduce their own exposure to global climate risks but also help fulfill legal obligations under the Paris Agreement's principle of common but differentiated responsibilities. While the most severe physical impacts fall on vulnerable countries, wealthier economies face significant risks as well – both directly through climate-related disasters and indirectly through disruptions to trade and supply chains. Emission reductions, wherever they occur, generate shared global benefits. By financing mitigation abroad, high-income countries can capture substantial returns by lowering their own economic exposure to climate hazards (Bolton et al., 2024; Bolton et al., 2025).

Countries at the receiving end may be incentivized to take climate action beyond the direct benefits from emissions reductions. Access to finance has a key relevance from a risk management perspective. Studies show a link between carbon emissions and sovereign bond yields, suggesting that countries taking climate action may be seen as lower-risk borrowers (Anyfantaki et al., 2025; Saxena/Singh, 2024). To make the most of these opportunities, better data and coordination are needed to allow private finance to flow more easily (Aphecetche, 2025).

At the same time, climate finance faces challenges, and emissions reductions projects in low- and middle-income countries financed by industrialized economies are often met with scepticism. Implementation of decarbonization policies is often hampered by weak governance frameworks, competing economic priorities and lack of access to finance and technology as well as political and societal headwinds. Critics argue that international carbon credits can undermine climate ambition. In practice, it is often difficult to ensure that projects financed abroad deliver genuine emission reductions and are truly additional to what the host government would have implemented anyway (Macintosh et al., 2025). Therefore, mechanisms are key that (a) foster the effective implementation of climate policies and (b) ensure that international transfers lead to a net increase in global climate ambition.

3. Creating incentives for governments to spur investments

3.1 Encouraging climate coalitions through reciprocity: The Carbon Border Adjustment Mechanism

Bridging frictions in international policy negotiations is essential for advancing effective climate cooperation. This calls for policy mechanisms that (a) foster coalition-building and raise collective climate ambition, and (b) generate reliable sources of climate finance. The latter is particularly important since international contributions in climate finance consistently lag behind pledges. While international negotiations on climate finance focus on headline targets, implementation pathways remain vague. The previous climate finance target of USD 100 billion paid by developed countries to help developing countries cut their emissions and adapt to climate change, was only reached in 2022 – two years past the deadline, and partly through the reclassification of existing commitments (Gabbatiss, 2024; Mitchell/Wickstead, 2024). At COP29 in Baku, the international community agreed on the New Collective Quantified Target (NCQG) of USD 300 billion per year by 2035, with the broader call on all actors to scale finance flows up to USD 1.3 trillion annually (UNFCCC, 2024). When and how these sums will be reached is still unclear. New policy instruments capable of mobilizing additional resources and delivering predictable, transformative finance are urgently needed (Bolton et al., 2025). The key challenges are to limit free-riding in international agreements and to create incentives that align donor countries' self-interests with funding emissions reductions in low- and middle-income countries.

The EU's Carbon Border Adjustment Mechanism (CBAM) is the most ambitious policy to date to prevent carbon leakage and limit free-riding on climate action. The CBAM aims to help the EU's energy-intensive industries (namely cement, iron and steel, aluminum, fertilizers, electricity and hydrogen) reduce emissions without being undercut by producers in countries with more lenient climate policies. Under the CBAM, imports of CO_2-intensive goods from countries without comparable carbon pricing face a levy, with a credit for any foreign carbon tax already payed. From 2026, the CBAM will gradually replace free allocations of emission allowances under the EU's emission trading system (ETS1), effectively aiming to protect European industries from relocation pressures in times of declining market liquidity. Beyond safeguarding competitiveness, the CBAM encourages third countries to regulate emissions, establishing reciprocity and thereby reducing incentives to free-ride on climate action.

The CBAM has the potential to gradually overcome the paradox of international climate cooperation by fostering a coalition of ambitious countries. In addition to protecting European industries, the CBAM incentivizes trading partners to introduce their own carbon pricing mechanisms, enabling them to capture revenues that would otherwise flow to the EU. Model simulations show that a climate coalition leveraging CBAM could cut global emissions significantly more than the EU acting unilaterally – even without US participation (Beaufils et al., 2024). Depending on the design and scope of the CBAM, it could encourage global emission reductions in the range of 2.5 to 9 times the emission reductions achieved by the EU ETS1 alone (ibid.). Early evidence confirms the coalition-building potential of CBAM: Following the EU's announcement to establish a border adjustment mechanism, Brazil, India, and Turkey began preparing national carbon pricing schemes aligned with EU standards, while China decided to expand its national carbon price to sectors affected by CBAM. These developments illustrate that the CBAM can function not only as a regulatory stick that imposes an economic burden on third countries, but also as a carrot that rewards compliance – an effect closely aligned with the climate club concept (Smith et al., 2024).

However, the CBAM imposes heterogenous adjustment costs on third countries, and concerns over high levels of exposure and vulnerability to the border levy have sparked diplomatic opposition among some states. A country's exposure to CBAM depends primarily on the carbon intensity of production in covered sectors and the degree of reliance on exports to the EU single market (Maliszewska et al., 2025). Opposition tends to be stronger in countries with lower public concern about climate change or limited capacity to develop climate-friendly innovations (Beaufils et al., 2023; Sabyrbekov/Overland, 2024). While wealthier EU trade partners are generally better positioned to decarbonize production processes and limit exposure, low- and middle-income economies that depend heavily on exports to the EU are the most vulnerable (e.g. Cornago/Berg, 2024; Beaufils et al., 2023; Lamy et al., 2024). Supporting these countries in their transition is critical to enhance CBAM's political acceptability, mitigate resistance, and foster the broad climate alliance it seeks to create. In addition to traditional climate finance and development aid, directing portions of CBAM revenues to vulnerable third countries could support their decarbonization efforts and help them adjust to the EU border levy.

3.2 Harnessing the benefits of international climate finance: Towards a funders' coalition and a more efficient distribution through jurisdictional reward funds

To address the shortfall in international climate finance, implementing a more efficient distribution mechanism for global transfers is key. Performance-based jurisdictional reward funds provide a promising way to avoid the pitfalls of currently existing climate finance schemes (Edenhofer et al., 2025b). Financing transfers to reduce the demand for fossil fuels in low- and middle-income countries is in the self-interest of industrialized and major emerging economies as they directly benefit from reduced climate damages. While emission reductions anywhere in the world directly lower damages, there exist still many low-cost abatement possibilities in low- and middle-income countries that have not adopted stringent climate policies yet. Realizing demand reductions in these countries thus allows to harness some low-hanging fruits. Therefore, it is economically rational for wealthier states to finance climate action abroad in addition to their domestic efforts to cut emissions.

Large economies that are net importers of fossil fuels have a particularly large incentive to finance fossil fuel demand reduction in third countries. Firstly, large economies profit significantly from the reduction of climate damages because high levels of wealth imply high losses due to climate impacts (Nordhaus/Boyer, 2000). While many low- and middle-income countries suffer disproportionally from the consequences of climate change, industrialized countries and major emerging markets have a lot to lose economically. Secondly, fossil fuel importing countries benefit from a decline in demand that will improve their terms-of-trade vis-à-vis exporters.

Model simulations show that due to their status as net fossil fuel importers and the size of their economies, the EU and China each have a self-interest to funding reductions in the demand for fossil fuels abroad. They both profit even from unilateral action, but financial flows and (global) benefits increase roughly four times when China and the EU cooperate (Edenhofer et al., 2025b). Assuming global Social Costs of Carbon of USD 200 per ton of CO_2, simulations show that transfers from the EU and China together would be incentive-compatible up to a level of USD 66 billion per year. Investing these funds in demand reductions for fossil fuels in low- and middle-income countries would cut global annual emissions by 1.06 Gt (ibid.). This corresponds to roughly 2.6% of global emissions in 2024. These estimates already account for carbon leakage – that is the relocation of high-emission activities caused by a decline in fossil fuel market prices – which weakens the impact of demand reductions to some extent but does not fully offset it.

Key to leveraging the benefits of international climate transfers is a mechanism that ensures reciprocity as well as an efficient distribution of the available funds. Performance-based jurisdictional reward funds offer a solution. These funds could operate at the country or regional level and offer financial rewards based on measurable outcomes, such as reductions in CO_2 emissions relative to a predefined reference level (Edenhofer et al., 2025b; Kalkuhl/Stern, 2025). This approach would solve a key problem of development finance: the crowding out of domestic investments caused by international finance for specific projects. In practice, international funding for specific projects, e.g. through the Clean Development Mechanism (CDM) or the new Paris Agreement Crediting Mechanism (PACM) respectively, often suffers from additionality problems (Calel et al., 2025; Probst et al., 2024) and crowding-out of government spending that offsets the level of international investments (Dykstra et al., 2019, Lu et al., 2010). Therefore, the additional climate benefits of individual projects cannot be guaranteed. Jurisdictional reward funds, on the other hand, would remunerate governments for the actual implementation of climate policy instruments (e.g. the introduction of a carbon price above a certain baseline). This approach would thus guarantee that climate action is raised above the status quo.

The striking advantage of such a "minilateral" approach is that it allows for the formation of a stable and self-enforcing climate funders' coalition that does not require global consensus. The ideal level of contributions hinges on the respective benefits for contributing countries that arise from the reduced climate damages and the terms-of-trade effect. Since the level of finance scales with the individual gains, the contributions

should automatically adjust as countries join or leave the coalition. By adapting the level of individual contributions to the level of benefits that arise from the cooperation with other actors, the mechanism creates reciprocity, thus easing the formation of an international climate funders' coalition. This approach is thus renegotiation-proof, works despite informational constraints and circumvents the dilemma of inaction caused by free-riding in international climate politics.

The jurisdictional reward funds could be capitalized through diverse funding channels. Model simulations suggest that a tax of roughly 3% on oil and gas imports by the EU and China would generate revenue levels consistent with their own economic self-interest (Edenhofer et al., 2025b). Such an import tax could be introduced without imposing additional costs on domestic consumers, as the cost increases from the tax would be directly offset by the benefits of improved terms of trade and a lower world market price for fossil fuels resulting from reduced demand – driven primarily by the jurisdictional reward funds. Additional resources could be raised by taxing international aviation or maritime shipping. Preliminary results suggest that taxing international aviation and maritime shipping at levels comparable to current ETS1 prices could yield around USD 140 billion per year if implemented globally. Alternatively, a share of the revenues from existing emissions trading systems or from the EU CBAM could be redirected to the jurisdictional reward funds. Channelling these revenues through the jurisdictional reward fund mechanism would enhance the effectiveness of international climate finance allocation.

4. Conclusions

There is a strong economic rationale for climate investments. As global warming continues, the overall costs of climate change – as captured by the SCC – keep rising, rendering mitigation investments increasingly attractive. Climate action can also open up new opportunities for innovation and economic growth. Moreover, reduced reliance on fossil fuel strengthens energy sovereignty and resilience in energy-importing economies.

However, while global investment needs are vast, the transition toward a low-carbon economy entails significant structural challenges. Balancing the long-term economic benefits against short-term adjustment costs lies at the core of the climate policy dilemma. In an era of rising geopolitical tensions, new approaches to climate diplomacy are needed. This paper highlights two mechanisms for enhanced international cooperation that align with the interests of the participating parties.

The CBAM has the potential to foster new climate alliances grounded in reciprocity. By incentivizing trading partners to adopt carbon pricing, the EU CBAM effectively promotes the formation of a climate coalition that can deliver emission reductions far beyond what the EU could achieve through unilateral action alone, while also curbing international free-riding on climate mitigation.

Fossil fuel importers can scale up climate action by establishing a funders' club combined with performance-based jurisdictional reward funds. Major fuel-importing economies, such as the EU and China, can enhance the effectiveness of international climate finance transfers by jointly funding reductions in fossil fuel consumption across low- and middle-income countries. Benefits arise via two channels: First, emission reductions lower climate damages, with a significant share of benefits accruing to large economies. Second, the induced decline in fuel demand improves importing countries' terms-of trade due to lower fuel prices. The mechanism makes use of lower mitigation costs in low- and middle-income countries, thereby delivering efficiency gains. The COP could provide momentum for the introduction of such a mechanism. Especially since the proposal aligns with the initiative of this year's COP Presidency to establish the Tropical Forests Forever Facility (TFFF), an investment fund to protect the rainforest.

Carefully designed minilateral approaches offer promising pathways as geopolitical divisions deepen. The recent failure by the International Maritime Organization (IMO) to adopt a joint Net-Zero Framework that would penalize high-emitting ships around the globe (Lo, 2025) underscores the importance of minilateral coalitions for climate finance. Such formats can circumvent cumbersome international negotiations and provide viable solutions despite political backlash from influential actors like the United States and persistent resistance in UN processes.

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Appendix: Literature

Acemoglu, D., Aghion, P., Bursztyn, L., & Hemous, D. (2012). The environment and directed technical change. *American Economic Review, 102*(1), 131–166.

Aldy, J., Pizer, W., Tavoni, M., Reis, L. A., Akimoto, K., Blanford, G., Carraro, C., Clarke, L. E., Edmonds, J., Iyer, G. C., McJeon, H. C., Richels, R., Rose, S., & Sano, F. (2016). Economic tools to promote transparency and comparability in the Paris Agreement. *Nature Climate Change*, 6(11), 1000–1004.

Anyfantaki, S., Blix Grimaldi, M., Madeira, C., Malovana, S., & Papadopoulos, G. (2025). Decoding climate-related risks in sovereign bond pricing: A global perspective. ECB Working Paper No. 3135. https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp3135~024090a8b9.en.pdf

Aphecetche, T. (2025). Investment barriers to sustainable finance: How to enable the transition in G20 economies. European Commission Economic Brief 083. https://doi.org/10.2765/50647

Barbier, E. (2016). Is green growth relevant for poor economies? *Resource and Energy Economics, 45*, 1–21.

Beaufils, T., Wanner, J., & Wenz, L. (2024). The potential of carbon border adjustments to foster climate cooperation. CESifo Working Paper No. 11429. https://www.ifo.de/DocDL/cesifo1_wp11429.pdf

Beaufils, T., Ward, H., Jakob, M., & Wenz, L. (2023). Assessing different European carbon border adjustment mechanism implementations and their impact on trade partners. *Communications Earth & Environment*, *4*, 131.

Beaufils, T., Jakob, M., Kalkuhl, M., Richter, P. M., Spiro, D., Stern, L., & Wanner, J. (2025). The security dividend of climate policy. Kiel Policy Brief No. 187. https://hdl.handle.net/10419/315745

Benayad, A., Burchardt, J., Veronica, C., Dany, O., Noßmann, A., Ploetz, J., Schroeren, D., Suess, E., Köhler-Geib, F., Kohn, K., Levinger, H., Römer, D., & von Kapherr, A. (2023). The climate financing roadmap: How development finance institutions can build bridges to unlock private capital. BCG/KfW Joint Publication for COP28. https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Studien-und-Materialien/The-Climate-Financing-Roadmap.pdf

Bevacqua, E., Schleussner, C.-F., & Zscheischler, J. (2025). A year above 1.5 °C signals that Earth is most probably within the 20-year period that will reach the Paris Agreement limit. *Nature Climate Change, 15*(3), 262–265.

Bhattacharya, A., Songwe, V., Soubeyran, E., & Stern, N. (2024). Raising ambition and accelerating delivery of climate finance. Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science. https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2024/11/Raising-ambition-and-accelerating-delivery-of-climate-finance_Third-IHLEG-report.pdf

Bilal, A., & Känzig, D. R. (2025a). The macroeconomic impact of climate change: Global vs. local temperature. NBER Working Paper No. W32450. https://ssrn.com/abstract=4826056

Bilal, A., & Känzig, D. R. (2025b). Does unilateral decarbonization pay for itself? NBER Working Paper No. 33364. https://doi.org/10.3386/w33364

Block, K., Li, M., Gärtner, J., & Lenzen, M. (2025). Geopolitical conflict impedes climate change mitigation. *npj Climate Action, 4*, 33.

Bolton, P., Kleinnijenhuis, A. M., & Zettelmeyer, J. (2024). The economic case for climate finance at scale. Policy Brief 09/2024, Bruegel. https://www.bruegel.org/policy-brief/economic-case-climate-finance-scale

Bolton, P., Edenhofer, O., Kleinnijenhuis, A., Rockström, J., & Zettelmeyer, J. (2025). Why coalitions of wealthy nations should fund others to decarbonize. *Nature, 639*, 574–576.

Burke, M., Hsiang, S. M., & Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature, 527*(7577), 235–239.

Calel, R., Colmer, J., Dechezleprêtre, A., & Glachant, M. (2025). Do carbon offsets offset carbon? *American Economic Journal: Applied Economics, 17*(1), 1–40.

Cichocka, B., & Mitchell, I. (2024). China as a provider of international climate finance. Center for Global Development. https://www.cgdev.org/publication/china-provider-international-climate-finance

CIRA – Cooperative Institute for Research in the Atmosphere (2025). North American wildfires of 2025. https://satlib.cira.colostate.edu/event/north-american-wildfires

Claeys, G., Le Mouel, M., Tagliapietra, S., Wolff, G. B., & Zachmann, G. (2024). *The macroeconomics of decarbonisation: Implications and policies.* Cambridge University Press.

Cornago, E., & Berg, A. (2024). Learning from CBAM's transitional phase: Early impacts on trade and climate efforts. Centre for European Reform. https://www.cer.eu/publications/archive/policy-brief/2024/learning-cbams-transitional-impacts-trade

Dykstra, S., Glassman, A., Kenny, C., & Sandefur, J. (2019). Regression discontinuity analysis of Gavi's impact on vaccination rates. *Journal of Development Economics, 140*, 12–25.

Edenhofer, O., Kilimann, C., Leisinger, C., Fuss, S., Kalkuhl, M., Pahle, M., Köhler-Geib, F., Börner, M., Kohn, K., Levinger, H., & Römer, D. (2024). Let it sink in: New governance and finance structures are needed to scale up carbon dioxide removals. PIK and KfW Research. https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Studien-und-Materialien/PDF-Dateien-Paper-and-Proceedings-(EN)/COP29_KfW-PIK-CDR.pdf

Edenhofer, O., Franks, M., Gruner, F., Kalkuhl, M., & Lessmann, K. (2025a). The economics of carbon dioxide removal. *Annual Review of Resource Economics, 17*, 301–321.

Edenhofer, O., Kalkuhl, M., & Stern, L. (2025b). How to scale up effective international climate finance by the EU? Tax coalitions and jurisdictional reward funds for the case of fossil fuel. Kiel Working Paper No. 2296. Kiel Institute for the World Economy. https://www.kielinstitut.de/publications/how-to-scale-up-effective-international-climate-finance-by-the-eu-tax-coalitions-and-jurisdictional-reward-funds-for-the-case-of-fossil-fuel-18265/

EDGAR (Emissions Database for Global Atmospheric Research) Community GHG Database, a collaboration between the European Commission, Joint Research Centre (JRC) and the International Energy Agency (IEA). https://edgar.jrc.ec.europa/report_2025

EPA – Environmental Protection Agency (2023). Supplementary material for the regulatory impact analysis for the final rulemaking, "Standards of performance for new, reconstructed, and modified sources and emissions guidelines for existing sources: Oil and natural gas sector climate review" – EPA report on the social cost of greenhouse gases: Estimates incorporating recent scientific advances. EPA. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf

ESABCC – European Scientific Advisory Board on Climate Change (2025). Scaling up carbon dioxide removals – Recommendations for navigating opportunities and risks in the EU. Publications Office of the European Union. https://doi.org/10.2800/3499931

European Council (2025). Europe's contribution to climate finance (in €bn). https://www.consilium.europa.eu/en/infographics/climate-finance/?utm_source=linkedin.com&utm_medium=social&utm_campaign=20251027-climate-finance&utm_content=visual#0

Fornaro, L., Pisani-Ferry, J., & Reichlin, L. (2025). The green transition: Challenging for all, but even more for middle-income countries. In J. Pisani-Ferry, B. Weder di Mauro, & J. Zettelmeyer (Eds.), *Paris report 3: Global action without global governance: Building coalitions for climate transition and nature restoration.* CEPR Press. https://cepr.org/publications/books-and-reports/paris-report-3-global-action-without-global-governance-building

Forster, P. M., Smith, C., Walsh, T., Lamb, W. F., Lamboll, R., Cassou, C., Hauser, M., Hausfather, Z., Lee, J.-Y., Palmer, M. D., von Schuckmann, K., Slangen, A. B. A., Szopa, S., Trewin, B., Yun, J., Gillett, N. P., Jenkins, S., Matthews, H. D., Raghavan, K., … Zhai, P. (2025). Indicators of global climate change 2024: Annual update of key indicators of the state of the climate system and human influence. *Earth System Science Data, 17*(6), 2641–2680.

Gabbatiss, J. (2024). Rich countries met $100bn climate-finance goal by 'relabelling existing aid'. *Carbon Brief.* https://www.carbonbrief.org/rich-countries-met-100bn-climate-finance-goal-by-relabelling-existing-aid/

Gilli, M., Calcaterra, M., Emmerling, J., & Granella, F. (2024). Climate change impacts on the within-country income distributions. *Journal of Environmental Economics and Management, 127.*

Greiff, M., & Kempa, K. (2025). Avoiding catastrophic climate change: Heterogeneous abatement costs and voting on redistribution in a threshold public good experiment. *Journal of Economic Behavior & Organization, 236.*

Hasna, Z., Jaumotte, F., Kim, J., Pienknagura, S., & Schwerhoff, G. (2023). Green innovation and diffusion: Policies to accelerate them and expected impact on macroeconomic and firm-level performance. *IMF Staff Discussion Notes, 2023*(008). https://doi.org/10.5089/9798400256950.006

Hochstetler, K. (2025). The green economy and the global South. *Regulation & Governance, 19*, 515–519.

Howard, P. H., & Sterner, T. (2025). Methodology matters: A careful meta-analysis of climate damages. *Environmental and Resource Economics.*

ICJ – International Court of Justice (2025). Obligations of states in respect of climate change. https://www.icj-cij.org/case/187

IEA – International Energy Agency (2021a). Net zero by 2050: A roadmap for the global energy sector. https://www.iea.org/reports/net-zero-by-2050

IEA – International Energy Agency (2021b). Share of CO2 emissions by region in the sustainable development scenario, 2040. https://www.iea.org/data-and-statistics/charts/share-of-co2-emissions-by-region-in-the-sustainable-development-scenario-2040

IEA – International Energy Agency (2024). Energy technology perspectives 2024. https://www.iea.org/reports/energy-technology-perspectives-2024

IEA – International Energy Agency (2025). World energy investment 2025. https://www.iea.org/reports/world-energy-investment-2025

IMF – International Monetary Fund (2025). World economic outlook: Global economy in flux, prospects remain dim. IMF. https://www.imf.org/en/Publications/WEO/Issues/2025/10/14/world-economic-outlook-october-2025

IMF – International Monetary Fund (n.d.). Fossil fuel subsidies. https://www.imf.org/en/Topics/climate-change/energy-subsidies

IRENA – International Renewable Energy Agency (2024). World energy transitions outlook 2024: 1.5°C pathway. https://www.irena.org/Publications/2024/Nov/World-Energy-Transitions-Outlook-2024

IPCC – Intergovernmental Panel on Climate Change (2021). *Climate change 2021: The physical science basis. Impacts, adaptation, and vulnerability. Contribution of working group I to the sixth assessment report of the Intergovernmental Panel on Climate Change.* Cambridge University Press.

IPCC – Intergovernmental Panel on Climate Change (2022). *Climate change 2022: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the sixth assessment report of the Intergovernmental Panel on Climate Change.* Cambridge University Press.

IPCC – Intergovernmental Panel on Climate Change (2023). *Climate change 2023: Synthesis report. Contribution of Working Groups I, II and III to the sixth assessment report of the Intergovernmental Panel on Climate Change.* IPCC.

Kalkuhl, M., & Stern, L. (2025). Aviation tax clubs: Evaluating proposals for mechanisms to raise revenue for global funds. SSRN. https://ssrn.com/abstract=5076531

Känzig, D. R. (2025). The unequal economic consequences of carbon pricing. Working Paper No. 31221. NBER. https://doi.org/10.3386/w31221

Kohn, K., Walter, H.-J., Grewenig, E., Röttmer, N., & Römer, D. (2025). The economic benefits of climate action: How decarbonization can enhance competitiveness and growth. KfW & Deloitte. https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Studien-und-Materialien/PDF-Dateien-Paper-and-Proceedings-(EN)/Economic-benefits-of-climate-action_Deloitte_KfW.pdf

Lamy, P., Pons, G., Van der Ven, C., & Azevedo, C. (2024). Turning the EU's carbon border adjustment mechanism into a green development tool. Policy Brief, April 2024. Europe Jaques Delors. https://www.europejacquesdelors.eu/publications/eu-cbam-a-green-development-tool

Lo, J. (2025). US-led alliance delays by a year the adoption of green shipping deal at UN. Climate Home News. https://www.climatechangenews.com/2025/10/17/us-led-alliance-delay-year-adoption-green-shipping-deal-nzf-imo-un/

Lu, C., Schneider, M. T., Gubbins, P., Leach-Kemon, K., Jamison, D., & Murray, C. J. L. (2010). Public financing of health in developing countries: A cross-national systematic analysis. *The Lancet, 375*(9723), 1375–1387.

Macintosh, A. Trencher, G., Probst, B., Barley, S., Cullenward, D., West, T. A. P., Butler, D. & Rockström, J. (2025). Carbon credits are failing to help with climate change — here's why, Nature. DOI: 10.1038/d41586-025-03313-z

Maliszewska, M., Chepeliev, M., Fischer, C., & Jung, E. (2025). How developing countries can measure exposure to the EU's carbon border adjustment mechanism. https://blogs.worldbank.org/en/trade/how-developing-countries-can-measure-exposure-eus-carbon-border-adjustment-mechanism

McWilliams, B., Tagliapietra, S., & Zettelmeyer, J. (2025). Reconciling the European Union's clean industrialisation goals with those of the Global South. Bruegel Policy Brief 18/2025. Bruegel. https://www.bruegel.org/policy-brief/reconciling-european-unions-clean-industrialisation-goals-those-global-south

Mesa Puyo, D., Panton, A. J., Sridhar, T., Stuermer, M., Ungerer, C., & Zhang, A. T. (2024). Key challenges faced by fossil fuel exporters during the energy transition. *IMF Staff Climate Notes, 2024*(001). https://doi.org/10.5089/9798400270147.066

Mitchell, I., & Wickstead, K. (2024). Has the $100 billion climate goal been reached? CGD Note 370. Center for Global Development. https://www.cgdev.org/publication/has-100-billion-climate-goal-been-reached

Moore, F. C., Drupp, M. A., Rising, J., Dietz, S., Rudik, I., & Wagner, G. (2024). Synthesis of evidence yields high social cost of carbon due to structural model variation and uncertainties. *Proceedings of the National Academy of Sciences, 121*(52), e2410733121.

Naran, B., Shankar, V., de Aragão Fernandes, P., Dixon, J., Burnett, J., Abraham, S., Stout, S., Connolly, J., Strinati, C., & Buchner, B. (2025). Global landscape of climate finance 2025. Climate Policy Initiative. https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2025/

NCEI/NOAA – National Centers for Environmental Information/ National Oceanic and Atmospheric Administration (2025a). Monthly global climate report for April 2025. https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202504

NCEI/NOAA – National Centers for Environmental Information/ National Oceanic and Atmospheric Administration (2025b). Assessing the U.S. temperature and precipitation analysis in July 2025. https://www.ncei.noaa.gov/news/national-climate-202507

Nordhaus, W. D., & Boyer, J. (2000). *Warming the world: Economic models of global warming.* MIT Press.

Paunov, C., Rochell, C., Labrue, L., & Planes-Satorra, S. (2025). What is unique about green innovation? OECD Science, Technology and Industry Working Papers, 2025(05). https://doi.org/10.1787/97e8232d-en

Peters, G. P. (2024). Is limiting the temperature increase to 1.5°C still possible? *Dialogues on Climate Change, 1*(1), 63–66.

Pisani-Ferry, J. (2021). Climate policy is macroeconomic policy, and the implications will be significant. Policy Brief Nos. 21–20. PIIE. https://www.piie.com/publications/policy-briefs/2021/climate-policy-macroeconomic-policy-and-implications-will-be

Probst, B. S., Toetzke, M., Kontoleon, A., Díaz Anadón, L., Minx, J. C., Haya, B. K., Schneider, L., Trotter, P. A., West, T. A. P., Gill-Wiehl, A., & Hoffmann, V. H. (2024). Systematic assessment of the achieved emission reductions of carbon crediting projects. *Nature Communications, 15*, 9562.

Qiu, M., Li, J., Gould, C. F., Jing, R., Kelp, M., Childs, M. L., Wen, J., Xie, Y., Lin, M., Kiang, M. V., Heft-Neal, S., Diffenbaugh, N. S., & Burke, M. (2025). Wildfire smoke exposure and mortality burden in the USA under climate change. *Nature*, 1–9.

Reisinger, A., Fuglestvedt, J. S., Pirani, A., Geden, O., Jones, C. D., Maharaj, S., Poloczanska, E. S., Morelli, A., Johansen, T. G., Adler, C., Betts, R. A., & Seneviratne, S. I. (2025). Overshoot: A conceptual review of exceeding and returning to global warming of 1.5°C. *Annual Review of Environment and Resources, 50*, 185–217.

Rennert, K., Errickson, F., Prest, B. C., Rennels, L., Newell, R. G., Pizer, W., Kingdon, C., Wingenroth, J., Cooke, R., Parthum, B., Smith, D., Cromar, K., Diaz, D., Moore, F. C., Müller, U. K., Plevin, R. J., Raftery, A. E., Ševčíková, H., Sheets, H., … Anthoff, D. (2022). Comprehensive evidence implies a higher social cost of CO2. *Nature, 610*(7933), 687–692.

Sabyrbekov, R., & Overland, I. (2024). Small and large friends of the EU's carbon border adjustment mechanism: Which non-EU countries are likely to support it? *Energy Strategy Reviews, 51*, 101303.

Salmon-Genel, M. (2025). Assessing the macro-fiscal risks from climate change: Concepts, methodological approaches, and insights from country practices. European Commission. https://economy-finance.ec.europa.eu/publications/assessing-macro-fiscal-risks-climate-change-concepts-methodological-approaches-and-insights-country_en

Saxena, K., & Singh, M. (2024). Investors reward countries for participating in climate agreements. *Nature Communications, 15.*

Smith, I. D., Overland, I., & Szulecki, K. (2024). The EU's CBAM and its 'significant others': Three perspectives on the political fallout from Europe's unilateral climate policy initiative. *JCMS, 62*(2), 603–618.

Thielges, S. (2023). The global shift away from fossil energy: A blind spot in climate foreign policy. SWP Comment No. 38. Stiftung Wissenschaft und Politik (SWP). https://doi.org/10.18449/2023C38

Tol, R. S. J. (2023). Social cost of carbon estimates have increased over time. *Nature Climate Change, 13*(6), 532–536.

Tollefson, J. (2025). Earth breaches 1.5°C climate limit for the first time: What does it mean? *Nature, 637*(8047), 769–770.

UNEP – UN Environment Programme (2024). Emissions gap report 2024: No more hot air … please! With a massive gap between rhetoric and reality, countries draft new climate commitments. https://wedocs.unep.org/20.500.11822/46404

UNEP – UN Environment Programme (2025). Emissions gap report 2025: Off target. https://www.unep.org/resources/emissions-gap-report-2025

UNCTAD – UN Trade and Development (2025). World investment report 2025. https://unctad.org/publication/world-investment-report-2025

UNFCCC – UN Framework Convention on Climate Change (2024). Decision -/CMA.6: New collective quantified goal on climate finance (Advance unedited version). United Nations Framework Convention on Climate Change, Baku. https://unfccc.int/sites/default/files/resource/CMA_11%28a%29_NCQG.pdf

Verpoort, P. C., Gast, L., Hofmann, A., & Ueckert, F. (2024). Impact of global heterogeneity of renewable energy supply on heavy industrial production and green value chains. *Nature Energy, 9*, 491–503. https://doi.org/10.1038/s41560-024-01492-z

WMO – World Meteorological Organization (2025a). Extreme heat impacts millions of people. https://wmo.int/media/news/extreme-heat-impacts-millions-of-people

WMO – World Meteorological Organization (2025b). State of the global climate 2024. WMO No. 1368. https://library.wmo.int/viewer/69455/download?file=WMO-1368-2025_en.pdf&type=pdf&navigator=1

World Bank (2024). The cost of inaction: Quantifying the impact of climate change on health in low- and middle-income countries. https://openknowledge.worldbank.org/server/api/core/bitstreams/bc51aeec-288e-4cbc-b4ca-b5a942057044/content

World Bank (2025). State and trends of carbon pricing 2025. https://www.worldbank.org/en/publication/state-and-trends-of-carbon-pricing

World Economic Forum (2023). The climate crisis disproportionately hits the poor. How can we protect them? https://www.weforum.org/stories/2023/01/climate-crisis-poor-davos2023/