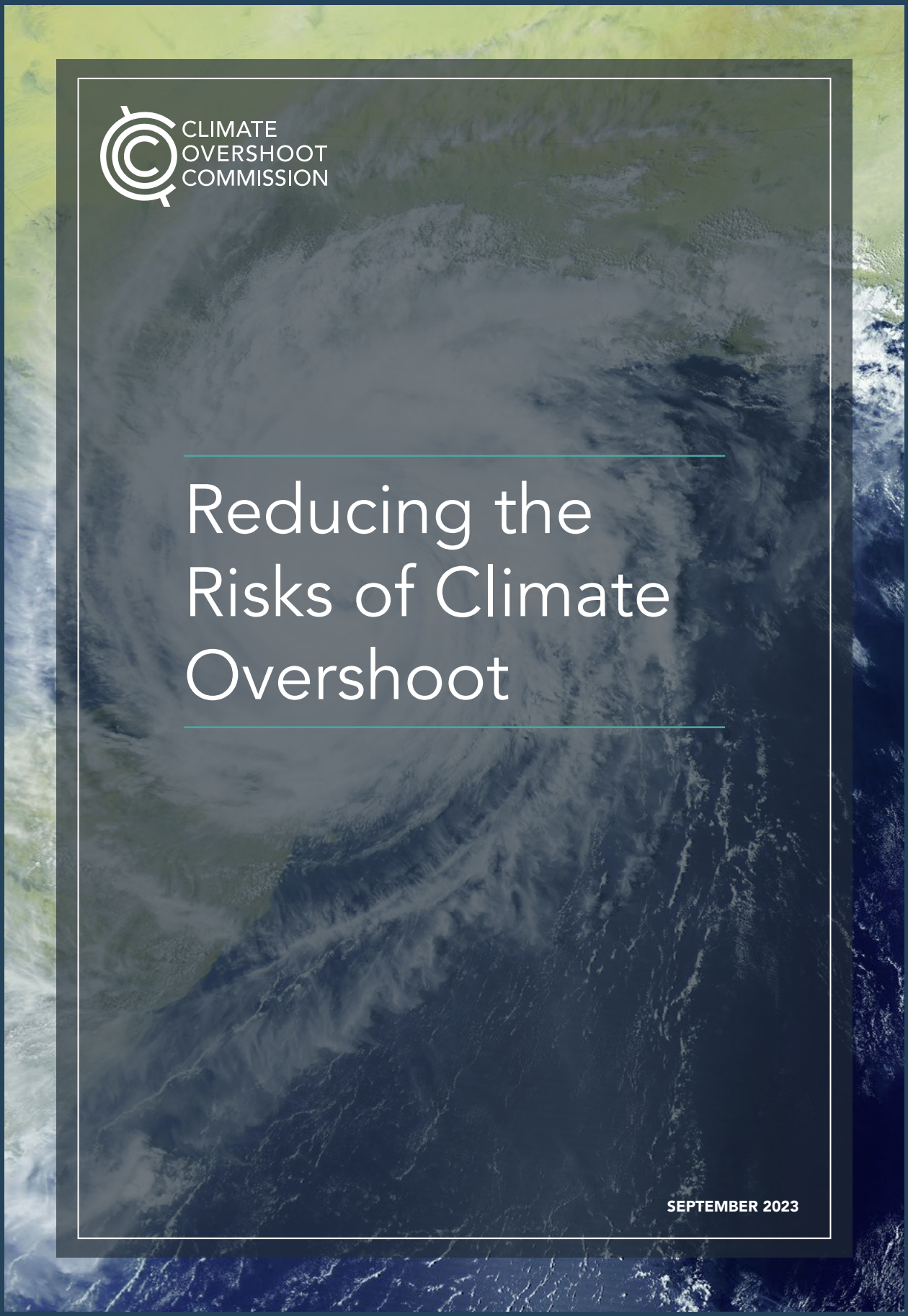

Reducing the Risks of Climate Overshoot

SEPTEMBER 2023

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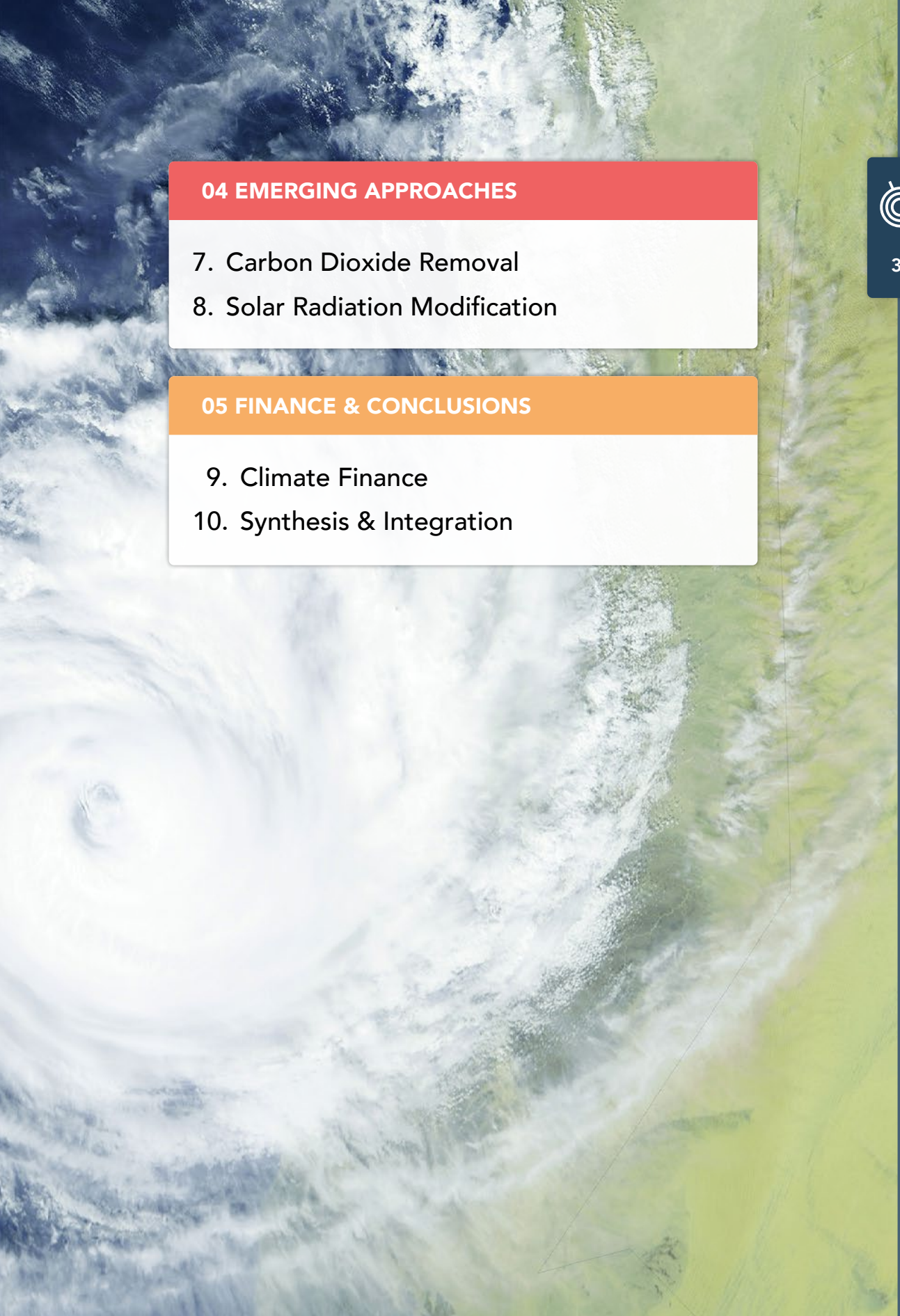

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CLIMATE OVERSHOOT COMMISSION

01

REDUCING THE RISKS OF CLIMATE OVERSHOOT

Executive Summary

SEPTEMBER 2023

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Foreword

Climate change stands as one of the most important and complex challenges confronting our world today. Its urgency is underscored by the frequency of record-breaking temperatures and the intensifying impacts felt not only by the most vulnerable nations in low-latitude regions but, increasingly, by industrialized countries as well.

Action is even more urgent. In 2018, the Intergovernmental Panel on Climate Change asserted that to likely limit global warming to 1.5°C, greenhouse gas emissions would need to be halved by 2030. As we approach the midpoint to that deadline, emissions have not decreased, but rather increased. The need for action is clear and immediate.

The Climate Overshoot Commission was convened as an independent body of twelve eminent global leaders in order to propose strategies to mitigate risks should global warming exceed the 1.5°C target. We are the first high-level group to holistically address all approaches – emissions reduction, carbon removal, adaptation, and solar radiation modification – in a comprehensive strategy, unfettered by typical political constraints. Our members, including former heads of government, national ministers, directors of intergovernmental organizations, environmental group leaders, and academic experts, bring a wealth of knowledge and experience. We were complemented by a Youth Engagement Group, whose six members from around the world bring both diverse expertise and the invaluable perspective of the generation that will bear the impacts of climate overshoot. Each of us speaks in our personal capacity. Our approach is comprehensive and unconstrained, and we are privileged to be guided by three distinguished international scientists specializing in climate change and Earth systems, ensuring our recommendations are rooted in the most recent scientific evidence.

While we offer numerous recommendations, our primary conclusions are as follows:

- The likelihood of global warming exceeding the 1.5°C goal of the Paris Agreement is alarmingly high and continues to rise.
- Policymakers should urgently address the escalating risks of climate change, particularly those impacting vulnerable countries, by considering the full spectrum of approaches.
- Emissions reductions must be prioritized and accelerated. This requires an ambitious and orderly phasing out of fossil fuels, as well as a clear differentiation between the pace of phase-out in industrialized and the least industrialized countries.
- Efforts to increase protection from impacts of a disrupted climate ("adaptation") should be expanded, along with the international financing to support them, as well as new mechanisms to plan, measure and anticipate at national level and across critical sectors such as agriculture.
- Carbon dioxide removal techniques should be developed and deployed to help achieve net-zero – and, ultimately, net-negative – emissions, balancing the benefits of biological and industrial methods, and enabling them through smart policies and financing.
- Countries should adopt a moratorium on the deployment of solar radiation modification and large-scale outdoor experiments that would carry risk of significant transboundary harm, while expanding research, and pursuing international governance dialogues.

Our journey has been enlightening. While the commissioners and youth group members were already well-versed in climate change and its risks, the additional strategies to manage these risks, including adaptation, carbon dioxide removal, and solar radiation modification, introduced further layers of complexity.

I wish to express my profound gratitude to the Paris Peace Forum for hosting the Commission, the Secretariat staff for their unwavering support, the Youth Engagement Group for providing a fresh perspective, our generous funders, the science advisors for their invaluable guidance, and, most importantly, the dedicated members of the Commission, whose voluntary contributions were indispensable to the success of this project.

I am confident that our collective efforts will serve as a catalyst for meaningful action in the face of our current climate crisis. We eagerly anticipate your support and collaboration in debating, deciding and implementing the strategies outlined in this report.

Bien cordialement,

Pascal Lamy

Chair of the Commission

Image credit: L.W. Unsplash

Executive Summary

The risk of climate overshoot – that is, of exceeding the Paris Agreement goal of limiting average global warming to 1.5°C – is high and rising, and with it the risk of worsening impacts on human health, food security, water availability, social stability, and ecosystems. No country would be spared from such consequences. The least industrialized countries, which have contributed the least to the problem but are generally more vulnerable, would suffer the most.

Yet none of this is inevitable. The means to change course exist. They also offer huge economic and political opportunities. People worldwide would welcome a safer, cleaner, more equitable world. All countries could, and should, act now to help bring about such a world.

The Global Commission on Governing Risks from Climate Overshoot (the "Climate Overshoot Commission") has considered the full range of response options to reduce the chances of overshoot and the risks from overshoot. In this report the Commission offers recommendations based on these deliberations.

The foundational strategy to avoid or limit overshoot is to accelerate deep reductions of greenhouse gas emissions – to stop making the problem worse. Doing so begins with a clear recognition that the era of fossil fuels must end. Countries need to implement a differentiated phase-out of fossil fuels and redouble their commitment to renewable energy sources, including in the form of a global green power target.

Industrialized countries should lead, aiming not only for net-zero but for net-negative targets – removing more carbon dioxide (CO_2) from the atmosphere than they emit – to create space for the least industrialized countries to pursue their clean and sustainable energy transitions while fighting poverty and fulfilling their development imperatives. To facilitate the global transition, we need to strengthen accountability, technology, and trade mechanisms.

Stopping emissions is essential but not enough on its own. Climate change is already causing harm across the globe. This harm is accelerating rapidly and will continue to grow. Thus, the second approach is to rapidly expand effective adaptation measures driven by an in-depth understanding of local climate risks and adaptation priorities. Countries and their partners should create robust metrics to assess the effectiveness of these measures. Such metrics should inform new country-led adaptation partnerships that align resilience efforts with sustainable development objectives. Particularly in developing countries, governments and their partners should bolster food security by promoting climate-resilient agricultural practices, supporting farmers, and conducting further research. Finally, we need to develop strategies to manage migration shifts induced by climate change.

Third, to help slow the increase of CO_2 in the atmosphere – and ultimately reverse it – carbon dioxide will need to be removed from the air on a significant scale and stored securely. There are many different methods for doing so, which vary in terms of their advantages and disadvantages. One way to categorize these methods is according to whether carbon is stored as organic or inorganic material. Policies for storing carbon in plants and soils should aim at maximizing the co-benefits of these approaches while minimizing the risk that carbon stored is re-released to the atmosphere. Methods that store carbon underground or in ocean waters but these methods pose physical and societal risks that must be mitigated. Countries should provide governance frameworks to scale up high-integrity carbon removal quickly and equitably, while cooperative efforts to finance their implementation should be pursued globally.

Lastly, and most controversially, solar radiation modification technologies – which would reflect sunlight back to space to reduce

Image credit: Marcus Spiske, Unsplash

temperatures – are gaining increasing attention. They are highly uncertain, would have unwanted or unforeseen consequences, and face significant opposition on social, political and ethical grounds. Early scientific evidence suggests that solar radiation modification could reduce some climate risks but would also introduce significant new risks. The world does not yet know enough to make informed decisions about solar radiation modification. The Commission approached the topic with great caution, opposing any use or assumption of use at this stage, but also supporting more research to produce a clearer picture of the efficacy, risks, and potential benefits of solar radiation modification, especially with regard to developing countries. And with little agreed international governance, there is an urgent need for more inclusive global dialogues on policy dimensions and political implications. For now, countries should adopt a moratorium on the deployment of solar radiation modification and large-scale outdoor experiments that would carry risk of significant transboundary harm, while expanding research, and pursuing international governance dialogues.

Climate action requires climate finance, yet the current level of such finance falls significantly short of what is needed. For low-income countries, climate and development

finance needs are closely intertwined, and the gap between promised and delivered climate finance, which has created distrust, must be closed. To do so, public actors must mobilize more resources. Development banks must be willing to accept more risk when lending. Debt relief and expanded official development assistance are also needed, alongside resilience instruments that can provide liquidity quickly, amply, and unconditionally when disaster strikes. Private capital flows should also be massively scaled up, especially to support emissions reductions, with the help of de-risking strategies, co-financing of investment projects, and other measures. Finally, new and underdeveloped sources of finance, including more transparent, effective, and efficient carbon markets, should be expanded.

Pursuing any single approach to reducing risks from overshoot – emissions reductions, adaptation, carbon removal, possibly solar radiation modification – may influence the effectiveness of other approaches. Both positive and negative spillovers must be identified and managed within a holistic framework. Overall, the recommendations made by the Commission constitute integrated components of a **CARE Agenda** for reducing risks from climate overshoot.

C

Cut emissions

Accelerate emissions reductions and consolidate decarbonization.

A

Adapt

Expand adaptation and fully mainstream into development.

R

Remove

Develop and deploy higher-quality carbon dioxide removal to help achieve net-zero emissions targets and beyond.

E

Explore

Adopt a moratorium on large-scale solar radiation modification and expand research and governance dialogue.

Recommendations contained in the report

Emissions reductions

First, governments should decide on a phase-out in production and consumption of all fossil fuels and accelerate their trajectories to this end, while broadening and deepening international discussions on this agenda.

- Reductions should be differentiated according to countries' needs and levels of development.
- Phased reductions of production and consumption (including subsidies) would follow.
- As phase-outs approach zero, essential-use exemptions should be provided for the hardest sectors to abate.
- Fossil fuel phase-out should ultimately – and quickly – be global in scope.
- The international community should simultaneously pursue a global green power target.
- Efforts to control short-lived climate pollutants should be boosted substantially.

Second, the world should recognize that developing countries will face particular challenges, and the global energy transition should be paired with imperatives of poverty reduction and development.

- The richest countries, including the oil exporting countries, need to reduce emissions faster and aim for net-negative targets by 2050 to give least industrialized countries more space to undertake their own transitions

Third, achieving an energy transition that meets the different needs of different countries requires ensuring that key facilitative conditions are met.

- Accountability systems should be strengthened to make available reliable and relevant information on the impacts and risks of public and private sector activities.
- International mechanisms should be established to accelerate the deployment of new technologies necessary to the energy transition and ensure worldwide access to them.
- Mutual recognition of national climate policies should be promoted, and attention should be given to the impact of climate-related trade measures in cases where they negatively affect the exports of poorer developing countries.

Recommendations contained in the report

Adaptation

First, because adaptation actions are primarily local in nature, international finance and policy support should be informed by a hyperlocal assessment of climate risks and adaptation priorities.

- A Global Climate Vulnerability Index would enable the design and delivery of effective and customized adaptation measures that meet each region's particular needs and preferences.

Second, to complement and support these assessments, standard metrics for adaptation should be developed.

- The development and application of a robust system of standard adaptation metrics will enable more strategic investments in climate resilience.

Third, to integrate these assessments and priorities into comprehensive action plans, the Just Energy Transition Partnership (JET-P) model – a country-led investment platform geared toward emissions reductions – should be replicated and reconfigured to support adaptation.

- A JET-P for adaptation would be based on a long-term, national-level strategy informed by national priorities, supported by international funding commitments, and complemented by a framework for disbursing and monitoring the investments.

Fourth, to strengthen the response capacity of these plans, global efforts to achieve "Early Warnings for All" should be supported.

Fifth, support should be boosted for efforts to address climate mobility – including migration, displacement, and planned relocation, driven by both slow-onset and extreme weather events.

- International climate migration, including from small island developing states, warrants particular attention among countries and relevant intergovernmental organizations.

Sixth, given the importance of agriculture and agrifood systems for adaptation to climate change in poor countries, supporting interventions that enhance their resilience is particularly critical.

Recommendations contained in the report

Carbon dioxide removal

First, governments should promote rapid expansion of higher quality carbon dioxide removal (CDR) featuring co-benefits and permanent storage, at scale and speed sufficient to materially reduce mid-century climate risks and contribute to keeping any overshoot as small and short as possible.

- A way to categorize carbon dioxide removal methods is according to whether the carbon is stored as organic or inorganic material: these methods differ in terms of their risks, challenges, and opportunities.

Second, large-scale CDR will depend on government action, so governments should undertake, require, or incentivize CDR innovation and expansion.

- Policies and programs should be designed to safeguard permanence, promote co-benefits, and manage risks of CDR methods while considering specific environmental and socioeconomic contexts.
- Biological carbon dioxide removal methods should aim at maximizing the co-benefits of these approaches while minimizing the risk that carbon stored is re-released to the atmosphere. Methods that store carbon underground or in the oceans should aim at maximizing secure storage while minimizing possible negative effects on people and ecosystems.

Third, in the short to medium term, international cooperative efforts to finance CDR implementation globally should be pursued.

Fourth, countries should follow the principle that those who cause harm have a duty to remedy it as the global basis for apportioning the costs of large-scale CDR.

- This includes carbon takeback obligations that would require fossil fuel companies to remove and store a steadily increasing proportion of the carbon generated by the products they sell.

Fifth, given present uncertainties about CDR methods and consequences, policies to promote rapid expansion of higher-quality CDR should be subject to periodic assessment and updating.

Recommendations contained in the report

Solar radiation modification

First, countries should adopt a moratorium on the deployment of solar radiation modification (SRM) and large-scale outdoor experiments. The moratorium should apply to any intervention with risk of significant transboundary harm, regardless of where it occurs, who carries it out or is responsible for it, what form it takes, or for what purpose.

- Governments adopting the moratorium should also call for its adoption by others.

Second, governance of SRM research should be expanded.

- Any outdoor SRM experiments should take place only in jurisdictions with an effective environmental regulatory regime.
- The data, methods, and findings of SRM research should be transparent, including to international audiences.
- SRM research should not be led by for-profit firms and should not be funded by sources with an interest in maintaining greenhouse gas emissions, such as fossil fuel interests.

Third, in parallel with strengthening SRM governance, SRM research should also be strengthened; and the two should co-evolve.

- Expanded research, for instance through joint North-South research projects and research led by scientists in the South, should boost the participation and build the capacity of researchers from developing countries.
- Given the broad impacts and need for SRM research to be perceived as unbiased and trustworthy, research funding should be transparent.
- International coordination of SRM research based on shared priorities shaped by policymakers with equitable North-South representation should be significantly strengthened.

Fourth, an international, independent scientific review and assessment of the best available evidence from SRM research should take place every few years.

Fifth, because the potential use of SRM raises multiple concerns, including novel and severe governance challenges, broad consultations and dialogues on these issues are needed.

Recommendations contained in the report

Climate finance

First, public bodies should mobilize and deliver more and better resources for developing countries.

- International financial institutions need to grow their balance sheets and take more risks.
- Special drawing rights can be used to finance development and climate activities.
- Resilience requires specific tools and instruments that can provide liquidity quickly, amply, and unconditionally when disaster strikes.
- More specific mechanisms could also be used more widely, such as Climate-Resilient Debt Clauses.
- The global trend of lowering official development assistance must be stopped and reversed, and this assistance should be more focused, prioritizing the poorest and most vulnerable.
- Domestic resources mobilization and reduction of inefficient and harmful expenditure can complement external financing.

Second, the private sector should massively increase its capital flows in support of climate action, in both developed and developing countries.

- Efforts to issue financial standards for sustainability-related disclosures should be supported.
- To lower the cost of capital, investment projects in developing countries need proper de-risking.

Third, new and underdeveloped sources of finance should be explored and strengthened.

- New taxes or levies could raise more revenues for climate finance by taxing activities or sectors that contribute to climate change.
- Transparent, effective, and efficient market mechanisms that can generate carbon credits for emissions reductions or removals should be expanded. An international public certification mechanism should verify the additionality, permanence and environmental integrity of such projects. The World Bank could be entrusted with the responsibility to immediately reinforce the standards currently used in the market.
- The Commission also suggests exploring mechanisms for making carbon credits eligible for small direct payments, especially for landowners who successfully preserve forested land or who restore degraded landscapes in developing countries.

Spillovers

First, in constructing a complete portfolio of climate finance projects, special attention should be paid to projects featuring positive spillovers.

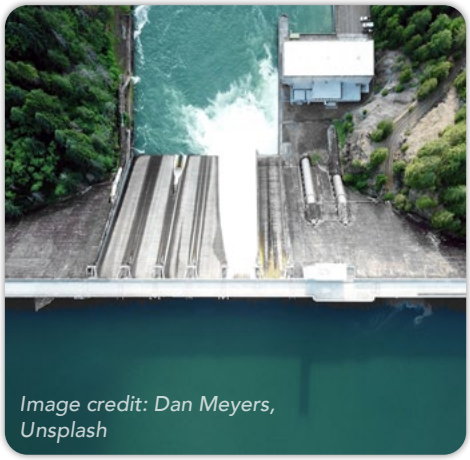
These include, for example, emissions reduction projects that also benefit adaptation, and responses with positive spillovers for broader sustainable development and biodiversity goals.

Second, forestry, and in particular efforts to slow and ultimately stop deforestation, should be given higher priority in climate policymaking.

Third, to ensure that CDR does not displace emissions cuts, CDR policies should not treat carbon removals as substitutable for feasible emissions reductions.

Fourth, in pursuing these different approaches, care must be taken not to exacerbate existing inequities, particularly when it comes to historically marginalized groups.

Image credit: Marcin Jozwiak, Unsplash



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About the Commission

The Global Commission on Governing Risks from Climate Overshoot, referred to as the "Climate Overshoot Commission," was conceived out of a critical necessity to address the potential governance gaps in the global response to climate change, specifically in relation to overshoot scenarios.

It emerged from a process initiated at the Paris Peace Forum, assisted by renowned academic institutions, the University of California at Los Angeles and Harvard University. In 2020, these dialogues led to the formation of a Steering Committee, marking a crucial step in the development of the Commission. This committee brought together an array of experts, policymakers, and civil society leaders, representing an equitable distribution of voices from both the global North and South. Their objective was to build a shared understanding of the novel governance challenges posed by climate overshoot and to devise strategies to address them. After a year of meticulous deliberation, the Steering Committee recommended the formation of a specialized commission dedicated to crafting a comprehensive, science-based global strategy for reducing risks should global warming goals be exceeded, independent of typical political constraints.

This recommendation was the start of the Climate Overshoot Commission, which was officially established in early 2022, with the following mandate:

1. Consider the risks entailed in overshooting 1.5°C and the range of response options for addressing such risks.
2. Identify possible benefits, likely costs, potential risks, and current global governance gaps for each policy option supplementing the critical focus on emissions cuts: adaptation, carbon dioxide removal, and solar radiation modification.
3. Identify combinations of options with the greatest potential to reduce climate risks, taking special account of vulnerable people and ecosystems, particularly in the Global South.
4. Engage in transparent consultations, including relevant stakeholder consultations on risks, policy options, and policy integration.
5. Develop a set of recommendations for an integrated strategy to reduce risks from climate overshoot, linked to the UN Sustainable Development Goals.
6. Share and disseminate these recommendations through a robust outreach campaign following publication of the Commission's work.

The Commission's second meeting, New York, September 2022

The Commission's functioning is supported by a group of premier international scientists, providing the Commissioners with the most recent and relevant research in the field. This ensures the Commission's strategies and recommendations are firmly grounded in robust science.

The Youth Engagement Group, composed of six members, followed and provided feedback on the deliberations of the Commission and the draft report, to help ensure the inclusion of diverse youth perspectives in the Commission's analysis. The Group is composed of Chandelle O'Neil, Shirmai Chung, Yuv Sungkur, Louise Mabulo, Jeremiah Thoronka and Alex Clark.

The Commission's operations are facilitated by a Secretariat. Hosted by the Paris Peace Forum, it consists of professional diplomats and academic experts who oversee the logistical aspects, briefing procedures, and drafting of key issue papers.

Upon conducting six in-person meetings in various global locations, the Commission compiled and released this final report, aiming at guiding future global dialogues about far-reaching actions required to govern climate risks. The Commission is now focused on disseminating this report and promoting widespread conversation about its recommendations, hoping to spark global debate and effective action.

Commissioners

Commissioners contributed to the report in their personal capacities. Their views may not reflect those of their affiliated organizations.

Mr. Pascal Lamy, Chair
Vice-President of the Paris Peace Forum; former Director-General of the World Trade Organization, France

Dr. Muhamad Chatib Basri
Former Minister of Finance of Indonesia

Ms. Frances Beinecke
President Emerita, Natural Resources Defense Council; board member, World Resources Institute, United States

The Right Honourable Kim Campbell
Canada's 19th Prime Minister, Founding Member of Club de Madrid

Mr. Jamshyd Godrej
Chairman of the board of Godrej & Boyce Mfg. Co. Ltd. and of the Council on Energy, Environment and Water, India

Ms. Arancha Gonzalez Laya
Dean, Paris School of International Affairs at Sciences Po, former Foreign Minister of Spain

His Excellency Mahamadou Issoufou
Former President of Niger Republic, President of Issoufou Mahamadou Foundation

Dr. Agnes Kalibata
UN Secretary-General's Special Envoy to the Food Systems Summit; President, Alliance for a Green Revolution in Africa, Rwanda

Ms. Hina Rabbani Khar
Former Minister of Foreign Affairs of Pakistan

His Excellency Anote Tong
Former President of the Republic of Kiribati

Prof. Laurence Tubiana
CEO of the European Climate Foundation; former Climate Change Ambassador and Special Representative for COP21 of France

Prof. Xue Lan
Cheung Kong Distinguished Chair Professor and Dean of Schwarzman College, Tsinghua University, China

The Commission's third meeting, Cairo, November 2022

Science advisors

Science advisors contributed in their personal capacities. The report may not reflect their own views.

Prof. Chris Field
Director of the Stanford Woods Institute for the Environment and Professor for Interdisciplinary Environmental Studies

Dr. Thelma Krug
Vice-chair, Intergovernmental Panel on Climate Change (through July 2023)

Prof. Michael Obersteiner
Professor and Director of the Environmental Change Institute, University of Oxford

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CLIMATE OVERSHOOT COMMISSION

REDUCING THE RISKS OF CLIMATE OVERSHOOT

Climate Overshoot

02

SEPTEMBER 2023

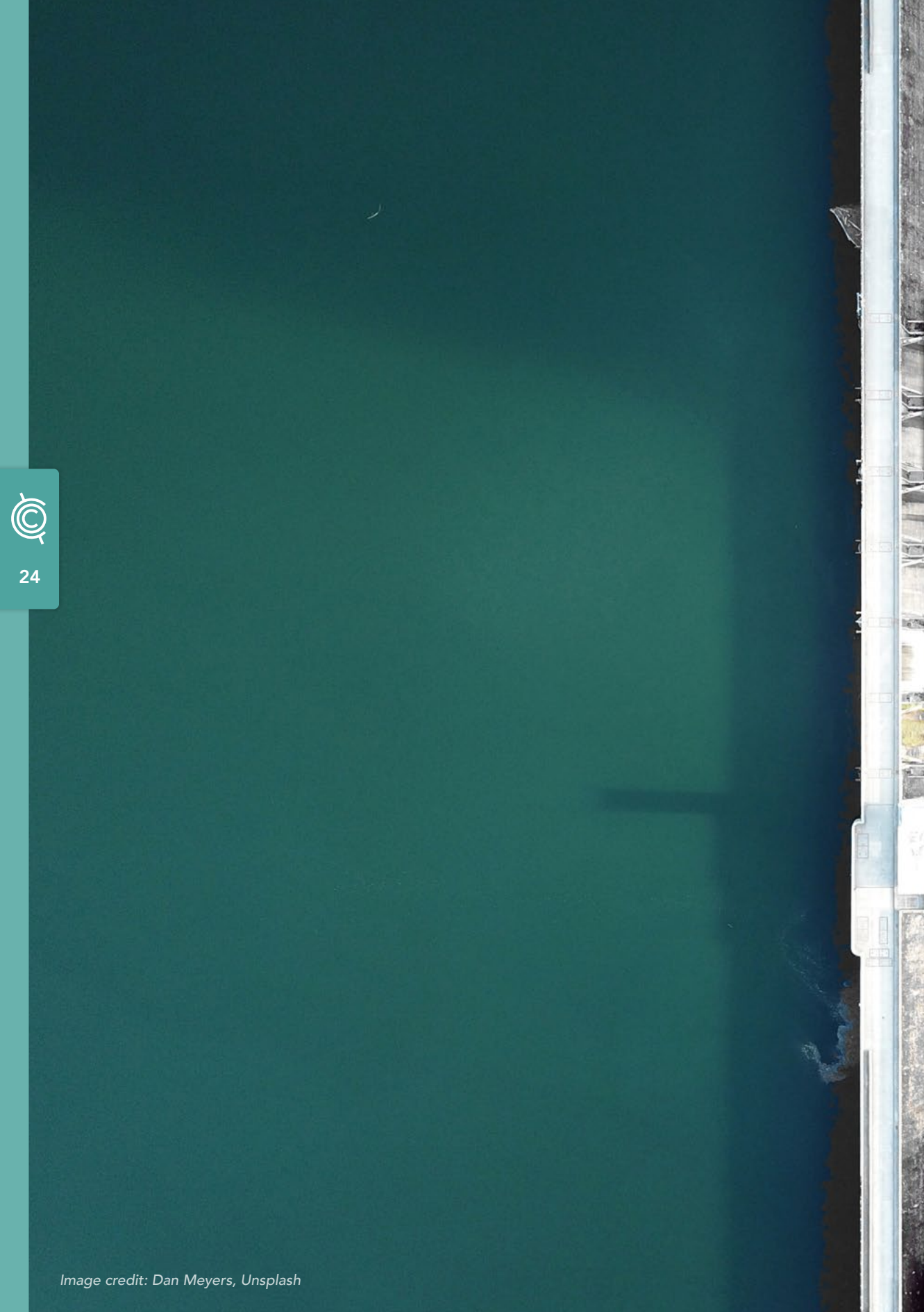


Image credit: Dan Meyers, Unsplash

1. Introduction

Key messages

- Limiting warming to 1.5°C remains an essential goal, but the risks of overshoot are high and rising.
- Governments, the private sector and civil society need to take action to reduce the probability, magnitude, and duration of any overshoot.
- Cutting emissions is the clear priority for action, but complementary approaches should be pursued.

Image credit: United Nations, Wikicommons

I**t was a historic moment.** On 12 December 2015, after two weeks of intense negotiations in Paris, world leaders at the twenty-first United Nations (UN) Climate Change Conference of the Parties (COP21) reached a breakthrough: the Paris Agreement. This is a legally binding international treaty that includes an overarching long-term goal to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels."[1] It was hailed as a landmark achievement, a sign of hope and solidarity in the face of a common threat. Since the Paris Agreement, the world's scientists have provided ample evidence that 2°C warming would present profound risks, and the priority must therefore be to avoid breaching 1.5°C.[2]

The global climate conversation has dramatically changed since then. International negotiations have continued on the rules and how to implement them. But eight years later, warming continues too rapidly. The global temperature has already risen by about 1.2°C,[3] and the UN Environment Programme (UNEP) warns that current policies will lead to a 2.6°C temperature rise by the end of the century.[4]

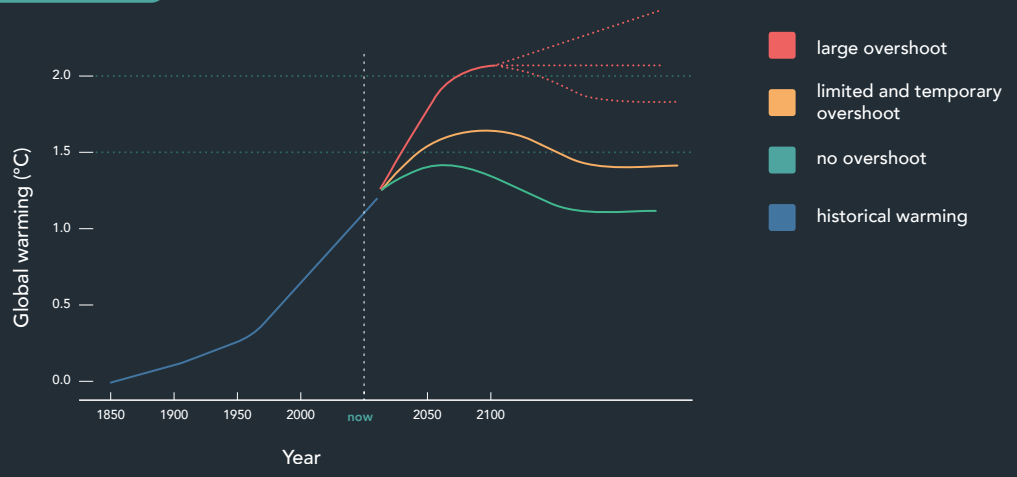
So, humanity faces a question. Can we resummon the pragmatic spirit of Paris and succeed in limiting temperature rise? There are numerous opportunities before us, which could not only curb the impacts of global warming but also help usher in a more just and equitable international system.

At the same time, there is no doubt as to the magnitude of the task – and the urgency of getting it right.

The 1.5°C goal is not just a number. The international community set this limit to signal the point beyond which it considers the risks of climate change to be unacceptable. The Climate Overshoot Commission understands "climate overshoot" to mean crossing this threshold. (See Figure 1.)

No country is being spared from the harm that climate change is already causing or from the increased risks that would come from additional warming. However, the least industrialized countries are generally more vulnerable and hence will suffer the most, even though

FIGURE 1 The concept of climate overshoot.



they have contributed the least to the problem. That is why climate change is an issue of justice. Because failure to act today would exacerbate future risks, it is also an intergenerational issue. And because impacts undermine the full enjoyment of human rights, climate change is a human rights issue.

Even at warming of 1.2°C, climate change is already having an impact everywhere: ice caps are melting, seas are rising, and weather extremes such as droughts, floods and fires are worsening.[5] These are jeopardizing billions of lives and livelihoods, especially in the most vulnerable and marginalized communities.

These risks will only intensify as the planet warms further and could trigger cascading and potentially irreversible harm to ecosystems, human health, food security, water availability, and social stability.

None of this is inevitable. The world has a wealth of tools with which to fight climate change; what is needed is the political will to apply them. The responsibility of policy makers is to show the benefits that climate action would bring and to help summon that will, while putting the interests of the poor first. Those who have contributed the least to the problem should not pay the highest price for it.

This is the starting point for the Global Commission on Governing Risks from Climate Overshoot – the "Climate Overshoot Commission" – an independent group of global leaders who have come together to consider the potential benefits, opportunities, and risks of a wide range of climate action approaches to minimize further increases in global temperatures and to reduce and manage the heightened risk of overshoot.

With this report, the Commission offers an integrated strategy for reducing the probability of breaching the Paris Agreement's goals, and limiting and managing the risks brought about by an overshoot should it take place.

At the most basic level, the world must do much more to cut greenhouse gas emissions as quickly and as deeply as possible, in order to avoid an overshoot. Every fraction of a degree matters.

Emissions continue to rise, however, and the remaining carbon budget for limiting warming to 1.5°C is shrinking, despite more than 30 years of effort and progress in some areas, and despite the manifest benefits of decarbonization. (See Figure 2.) The Commission recognizes that the risk of climate overshoot is significant and imminent and requires us all to act now.

That is why the Commission examines all the potential tools in the toolbox, including those that were not significantly discussed when the Paris Agreement was negotiated.

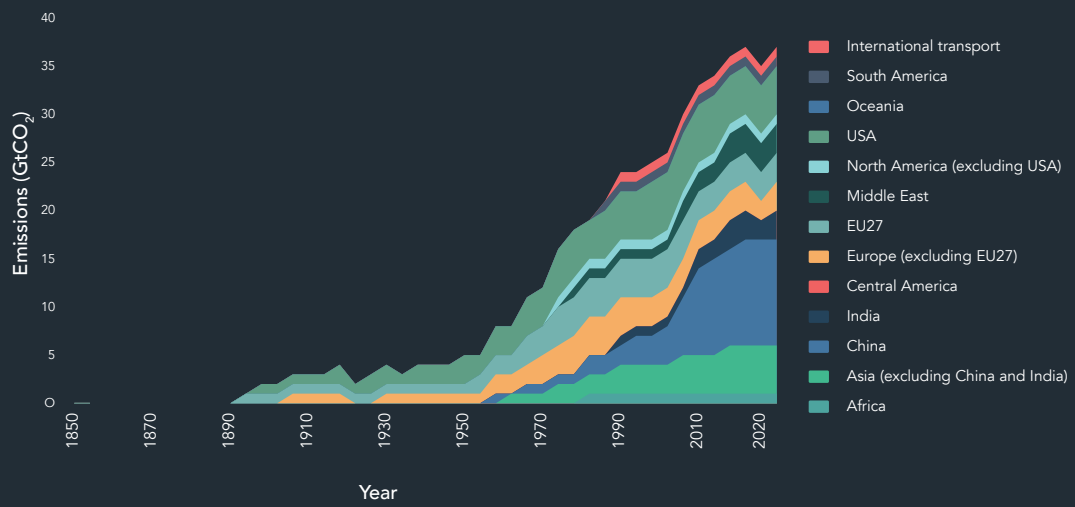
As a starting point, this requires understanding what the approaches are, evaluating their potential, their limitations and their interdependencies, and exploring policies to maximize their benefits. Not all will be adopted, and some may be rejected as impractical, too costly, or too risky. All should be considered, however.

None of these questions are simple or straightforward. In many cases, decisions go well beyond technical expertise, and enter the realms of politics, ethics and philosophy. What kind of a world do we want? What lines must we not cross? In all cases, finding answers requires listening to a wide range of viewpoints often poorly represented in policy discussions. And governance structures – some novel – should be created to do so meaningfully and effectively.

The Commission embraces these complexities, as negotiating them is the only route to effective, just, and equitable action that benefits all people and the planet.

There is a better world on offer, should we choose to grasp it. But getting there will require faster, deeper, and better governed climate action, and a focus on what is doable. The Commission hopes this report highlights the dramatic benefits such action would bring and inspires a new way of acting to safeguard our shared future.

FIGURE 2 CO_2 emissions to date.[6]



2. The Origins of Climate Overshoot

Key messages

- Thirty years of climate policy and action have brought about significant progress but have also fallen short in key areas and produced insufficient results.
- The primary reason for climate change – and the growing risk of overshoot – is a continued reliance on fossil fuels.
- Climate change has contributed to growing international tensions.
- Finding the requisite political will to fight climate change requires new approaches and action grounded in justice and equity.

Image credit: Chris Leboutillier, Unsplash

The story of our collective lack of sufficient action on climate change is complex, involving politics, economics, justice, and more. It is also one of missed opportunities and vested interests.

It is a story that reveals the limits of our current institutions to deal with a problem that transcends borders and generations, as well as a collective failure to adequately envisage the healthier and happier world that concerted action could achieve.

The first part of the story is about recognition of the problem and attempts to solve it.

The UN Framework Convention on Climate Change (UNFCCC), adopted in 1992, remains the foundational international treaty on the issue. It set out the objective of stabilizing greenhouse-gas concentrations in the atmosphere at a level that would prevent dangerous harm. It also recognized the principle of "common but differentiated responsibilities," meaning that developed countries should take the lead in reducing emissions and provide financial, technological, and capacity-building support to developing countries.[7] These tenets still hold today.

The UNFCCC treaty has been followed by yearly rounds of negotiations and agreements, with important steps taken in meetings in Copenhagen in 2009 and Cancún, Mexico, in 2010, culminating with the Paris Agreement in 2015. The Paris Agreement functions as a "regime complex," where the global objective of holding temperature rise to well below 2°C works as the umbrella and is part of the "top-down" dimension. It is based on national pledges – Nationally Determined Contributions (NDCs) – that gradually ratchet up in ambition. Although the pledge-making process is legally binding, meeting those pledges is not, and individual countries determine the content of their NDCs (subject to an expectation that ambition will rise). This arrangement is complemented with legally required regular processes for transparency and stocktaking.

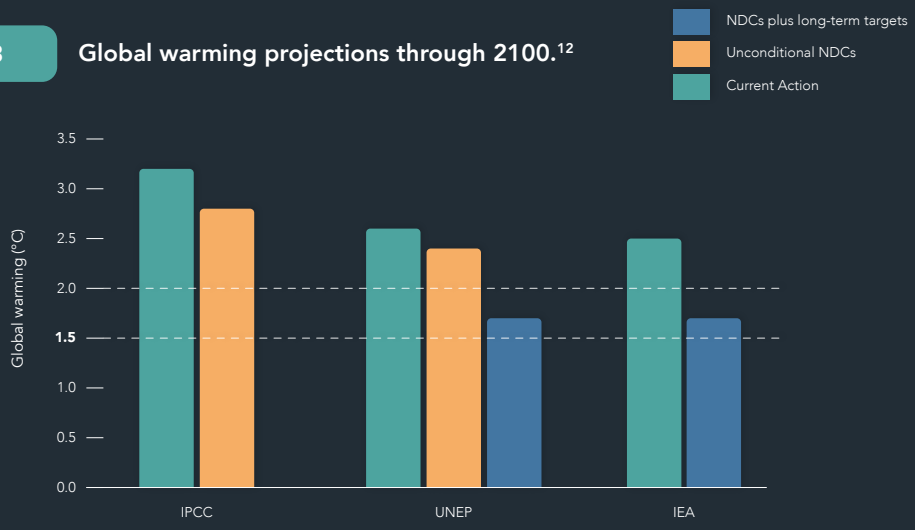
The second part of the story is about the insufficient progress in implementing these commitments.

Since 2015, the world has witnessed a remarkable shift in the direction and momentum of climate action. Many countries are strengthening their commitments, with nearly all industrialized countries having committed to achieve "net zero" emissions, mostly by 2050 and – to varying extents – through binding laws.[8] An increasing number of countries – including most high-income countries – are succeeding in lowering their emissions even while their economies continue to grow.[9] Some countries are industrializing in ways that are less emissions-intensive than in the past.

New initiatives have been undertaken, such as the alignment of the portfolios of multilateral development banks (MDBs) with the Paris Agreement, International Maritime Organization negotiations to reduce emissions from shipping, and further reductions in hydrofluorocarbon use through the Kigali Amendment to the Montreal Protocol. Additional action has come from informal coalitions such as the Network of Central Banks and Supervisors for Greening the Financial System and the Glasgow Financial Alliance for Net Zero. Indeed, global emissions may have recently peaked.

Expected global warming by 2100 has fallen from a projected 3°C to 4°C increase – an apocalyptic scenario that was still plausible a few years ago – to a rise of 2°C to 3°C.[10] But that is still far too high. (See Figure 3.) On World Meteorological Day 2023 the UN Secretary-General, António Guterres, warned:

FIGURE 3 **Global warming projections through 2100.**[12]



"Every year of insufficient action to keep global warming below 1.5°C drives us closer to the brink, increasing systemic risks and reducing our resilience against climate catastrophe."[11] We must heed this warning and maintain the pressure for more action. The world is probably not going to stop acting altogether but cannot afford to be complacent.

The world needs more – and quicker – progress. The unfortunate fact is that the chance of overshoot is high and increasing. The Intergovernmental Panel on Climate Change (IPCC) concludes that even under the most optimistic scenarios, it is "more likely than not" that we will exceed 1.5°C.[13] A resilient, liveable future is still available to us, but there is a rapidly narrowing window for humanity to take decisive action. Reaching our targets is made more challenging by the fact that humans' otherwise harmful aerosol pollution in the lower atmosphere actually cools the planet and masks some warming, estimated to be 0.7°C globally.[14] As we reduce this pollution, this suppressed warming will be unveiled.

The third part of this story is about the opportunities and challenges of implementing climate change solutions.

The opportunities are massive. Innovation has dramatically lowered the cost of alternatives to fossil fuels, especially solar and wind energy, making them competitive with or cheaper than fossil fuels in many markets. Between 2010 and 2021, the cost of solar projects fell by 88 percent and the cost of onshore wind by 68 percent.[15] China has been a driving force behind these cost reductions.[16] As a result, global renewable energy capacity has been forecast to grow by almost 75 percent between 2022 and 2027, accounting for more than 90 percent of global electricity capacity expansion over that period.[17] China is also leading the world in its deployment of electric vehicles.

Countries are also taking enormous strides in improving energy efficiency. India's Unnat Jyoti by Affordable LEDs for All program, for instance, is now the world's largest zero-subsidy domestic lighting program, addressing high electrification costs and high emissions from inefficient lighting. The program has distributed nearly 370 million LEDs since 2015 and helped reduce the cost of LED bulbs by 85 percent.[18]

> *Every year of insufficient action to keep global warming below 1.5°C drives us closer to the brink, increasing systemic risks and reducing our resilience against climate catastrophe.*

The European Union (EU) and the United States (US), with their FitFor55 and Inflation Reduction Act legislation, have put in place comprehensive – yet different – policies to accelerate the transition to clean energy.

The benefits that could be derived from a low-carbon economy have become clearer, as many authoritative bodies have emphasized, including the New Climate Economy Commission.[19] These benefits include not only avoiding the worst impacts of climate change, but also creating jobs, improving health, reducing inequality and enhancing resilience.

The climate movement has steadily been growing. Constituencies – especially young people – are energized and putting pressure on governments all around the world. The urgency is shared at all levels of development and across geographies. India, for instance, is the prime mover behind the International Solar Alliance to promote solar power in tropical countries. Climate change is central to the international agenda.

Yet the gap between goals and reality remains. Key issues to address include:

- **The collective action problem:**

Climate change is a global problem that requires global action and cooperation. The Kyoto Protocol "top-down" efforts to advance emissions reduction commitments from countries fell short in terms of participation and had little impact on emissions.[20] The commitments that countries were willing to make were too weak, the prospect of noncompliance led to Canada's withdrawal and the US, a key player, refused to join.

The hybrid approach pursued by the Paris Agreement – a mix of top-down and bottom-up – sought to reverse this dynamic. The Agreement and its temperature goal became the reference point for all actors around the world, from national governments to cities, private finance, corporations, and others. The Paris Agreement serves as the umbrella under

which institutions outside of the UNFCCC and different sectors can identify the agreements, pathways and tools necessary for them to meet the Paris goal. This is complemented by the Paris Agreement's mandated regular cycle (the "ratchet process") of NDCs to become more ambitious over time, as economies, technologies and societies advance.

The Paris Agreement was a big step forward, with a strong collective decarbonization commitment. Nevertheless this should be a living and learning framework. It has to be completed under this overarching umbrella by adequate mechanisms, continuing to strengthen existing ones such as amendments to the Montreal Protocol, the International Maritime Organization, the Financial Stability Board, and the climate chapters of the different summits; and new ones, such as methane agreements, or treaties on forest or ocean protection.

- **The lock-in effect:**

Industrialization has been driven by fossil fuels that were cheap only because their full environmental and social costs were not apparent for many years, and because governments had subsidized them. Over time, fossil fuel use became deeply embedded in modern production processes and consumption patterns, creating path dependencies that resist change. Fossil fuel companies are powerful and highly mobilized to push back against climate action. They have significant organizational and political advantages compared to the general public as well as strong incentives to oppose measures that would put a price on carbon or otherwise constrain fossil fuel use. They frequently succeed in blocking strong national climate policies by lobbying governments and officials and producing misleading public communications, weakening global climate action. In addition, governments seeking to phase out public subsidies often face stiff resistance.

- **The equity gap**:

Developed countries have contributed more to the problem and are less vulnerable to its impacts – even if they are not immune. Developing countries have contributed less and are more vulnerable, while having less capacity to adapt or cut emissions. The interests of the most industrialized countries disproportionately drive the agenda, while those of low- and middle-income countries are frequently overlooked, ignored or treated as less important. Despite their financial means, industrialized countries have not made it a priority to meet the least industrialized countries' critical need for climate finance. The poorest countries, with limited financial resources, feel that they have to choose between cutting emissions and other pressing issues such as reducing poverty.

Large emitters and industrialized countries across the North and the South who have the capacity to do more must not escape their responsibility to reduce emissions more quickly. Failures to fully address the needs and responsibility of all countries have contributed to an erosion of trust within international climate negotiations and made climate cooperation even more difficult to achieve. As economic growth has increased in large parts of the developing world, global agreement on differentiated burden-sharing has become more difficult.

- **Behaviour and lifestyles**:

The choices that people have made, individually and collectively, especially consumers in developed countries, have contributed to the climate crisis. But we can make choices that are more sustainable and help reduce emissions. Initiatives that motivate people

Image Credit: Vincent ma janssen, Pexels

to adopt environment-friendly behaviour and take simple yet meaningful actions in their daily lives to reduce their environmental impact should be encouraged. Public policies can provide positive incentives, appropriate infrastructure and institutions, and market opportunities.[21]

The final part of this story is yet to be written.

It will depend on whether the world can overcome the barriers and challenges that have prevented stronger action thus far. And it will depend on summoning the political will to act, and mobilizing the necessary public support, financial resources, and technological innovation.

There are some reasons to be optimistic. It is not a small achievement that, in the years following the Paris Agreement, public policies around the world have moved, even if insufficiently, in a better direction.

This may be the first time in human history that a global agreement has triggered such multifaceted and distributed policy changes and provides some grounds for optimism. Let us not underestimate what has been achieved, even while recognizing how much yet needs to be done, and how quickly.

How do we wish to be remembered? As the generation that shied away from the challenge, and the opportunity, of our age? Or as leaders who, when tested, lived up to the moment and laid the groundwork for a better future?

We know more action is possible and that the problem in front of us is solvable. The Climate Overshoot Commission challenges those in positions of responsibility and leadership, in government, in business, in civil society, to seize the opportunity and act.

3. Expected Impacts from Climate Overshoot

Key messages

- Climate impacts and risks are already severe at 1.2°C warming, and they are increasing.
- Heat-related impacts, extreme weather events, and sea level rise pose direct threats to the health, security, and economic well-being of all countries and communities.
- The damage caused by an overshoot will depend on its size and its duration. Every tenth of a degree matters. The greater the overshoot, the worse the impacts.

Image credit: Arthur Brognoli, Pexels

In August 2022, a month after a record-breaking heat wave scorched southern Pakistan, the skies opened up and unleashed a torrent of rain. The monsoon season, which usually brings replenishment to the parched land, turned into a nightmare. The rain was too much, too soon. The Indus River overflowed its banks, dams were breached, drains clogged and burst, and the water swept away everything in its path: houses, crops, roads, bridges, cars, animals, people. One-third of the country was submerged.

The floods were the deadliest and costliest in Pakistan's history, claiming more than 1,700 lives, displacing millions of people, and destroying crops and infrastructure worth roughly 30 billion USD.[22] **They were partly caused by a combination of factors that were influenced by climate change: higher temperatures, more moisture in the atmosphere, more variable rainfall patterns, and more extreme weather events.**[23]

Since the Climate Overshoot Commission was launched in early 2022, many members have witnessed first-hand the wrath of a warming planet. As the Commission completed its report, several days in July and August exceeded mutiple global temperature records on the planet.[24] If anyone doubted the potential costs of climate change, those doubts have been increasingly difficult to maintain.

In different combinations, more frequent and more intense heat waves, droughts, wildfires, crop failures, storms, and disease are all affecting every region of our fragile planet.[25] They form an alarming pattern of increasing climate variability and extremes that will only worsen as the world continues to warm, posing rising threats to human health, food security, water security, economic growth, social stability, and ecosystem integrity.[26]

The impacts of overshoot would depend on how much and for how long we exceed temperature goals. The impacts of greater warming, such as 2°C, would be substantially more severe.[27] In all cases, they would be felt most directly at the local level, where communities and habitats would suffer in different ways depending on their location, vulnerability, and capacity to adapt. Climate change would undermine all of the Sustainable Development Goals (SDGs).[28]

This section explores some of these expected impacts across six dimensions: **heat, extreme weather events, public health, ecosystems, and possible irreversible and catastrophic changes in natural systems** – called tipping points by some.[29]

The aim is not to preach doom but to illustrate the likely consequences of our collective choices and actions. The climate crisis was not inevitable; it is a result of human decisions and behaviours. Humanity still has the time and opportunities to change course. But we need to act fast, and decisively.

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Heat

The most direct and significant impact of climate overshoot, is excess heat. The ramifications of rising heat harms those in already warmer climates - most countries are not prepared for a hotter world.

Extreme heat and heat waves pose direct threats to people, causing heat stroke and exacerbating respiratory and cardiovascular diseases. People who are already vulnerable are particularly at risk. Extreme heat events can be fatal.

More heat would cause serious harm to food production and security, especially in regions where crops are already near their thermal limits. It would raise water demand for irrigation and increase evaporation, exacerbating water stress in many regions.

An increase in global electricity demand for indoor cooling would put added strain on grids and push up electricity prices, especially in developing countries.

More heat would also affect economic productivity and growth. Outdoor workers in sectors such as agriculture, construction, and tourism would face reduced working hours and increased health risks. School would be more difficult to attend.

Here again, the gap between rich and poor countries is likely to rise. Within countries, people living in marginal areas with limited access to resources and services would suffer most – from heat-related illness and death, food insecurity, water scarcity, and income loss.

Hotter conditions tied to overshoot would increase the likelihood of large-scale intergroup conflicts, including civil wars, in Africa and elsewhere.[30] For instance, climate change is driving desertification in the Sahel, reducing the availability of water and land for agriculture and pastoralism. Scarcity of resources has led to conflicts between farmers and herders – conflicts that terrorist and non-state armed groups have exploited. These clashes in turn have displaced millions of people, creating humanitarian emergencies and undermining political stability and governance.

Areas currently on the margins of human habitability may become uninhabitable as increased wet-bulb temperature – a measure of combined heat and humidity – forces people to adapt or if that is not a feasible option, to migrate. Ecosystems currently experiencing heat stress may not survive in their present form.

Rising sea levels would erode coastlines, cause flooding and salinization, and damage infrastructure and ecosystems. People on small islands face existential risks from sea level rise that threatens their islands' habitability and their economic foundations, confronting them with the unwelcome prospect of migration. (See Box 1.)

Ocean warming, which contributes to sea level rise via thermal expansion, will also intensify tropical cyclones, disrupt marine ecosystems and increase the risk of coral bleaching. People will suffer economic dislocation and food insecurity caused by disruptions to fisheries.

Extreme weather

Overshoot would entail more extreme weather events such as storms, heavy rain, drought, wildfires, and coastal flooding.

Small islands, which already suffer damage from tropical cyclones, would face an even greater threat from more intense storms. Increasing drought conditions would plague Africa as well as Central and South America, aggravating water scarcity, reducing crop yields and making fisheries less productive. Flooding would pose growing threats to inland and coastal communities in Asia. Increased flooding and droughts would also cause harm in Europe and North America. Lost livelihoods and the related economic harm would exacerbate poverty.

Again, these shocks would be felt unevenly across the world but most severely in the poorest countries and regions. Developing countries are more physically exposed to climate hazards, as many are located in regions with higher temperatures, more variable rainfall, and lower elevation. They are also more economically vulnerable to climate risks and less able to adapt to climate impacts, lacking the financial, technical, and technological resources needed to reduce

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their exposure and vulnerability, enhance their resilience, and recover from shocks.

Developed countries would not be spared the impacts of climate overshoot, however. They are also exposed to climate hazards such as worsening heat waves, droughts, floods, and storms. In Europe, increased coastal and inland flooding would cause damage and disruption, and increasing droughts would reduce water availability and food production. Worsening droughts in North America would pose growing risks to water, food, and energy security. This year, wildfires in Canada have cost billions of dollars and blanketed large swathes of North America with polluted air. Increased fire risk has already made many Californian homes uninsurable.[31]

While the greater adaptive capacity of developed countries would enable them to cope with climate harm more readily than their counterparts in the South, rich countries also have limits and barriers to adaptation. Their economies are vulnerable to climate risks and extreme events that can disrupt complex and interconnected systems on which they rely. Overshoot would curb economic growth and cost jobs throughout the North.[32] Developed countries would also face increasing pressures from migration, conflict, and humanitarian crises.

Public health

These same climatic trends would threaten global public health, increasing people's exposure to infectious diseases, malnutrition, mental stress, and air pollution.

The conditions for disease transmission would worsen. People in Central and South America and Africa would be at increased risk of epidemics including malaria, dengue, and other mosquito-borne diseases. People in North America and Europe would be at increased risk of Lyme disease.

Image credit: Jo Anne McArther, Unsplash

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The global population at risk of undernutrition would increase, posing a threat especially to children and pregnant women in low-income countries, where food insecurity is prevalent and climate sensitive. More extreme weather events like heat waves, wildfires, storms, floods, and droughts would jeopardize public health and safety. Wildfires, for instance, produce smoke and haze that can travel long distances and harm large populations.

Stalled development caused by exceeding 1.5°C warming would also undermine public health indirectly by compromising healthcare systems and eroding socioeconomic conditions necessary to public well-being. The global population at risk of mental distress would increase, affecting especially those who are directly or indirectly exposed to climate impacts such as extreme events, displacement, migration, and poverty.

Natural ecosystems

The world already faces a biodiversity crisis triggered by human activity, with many species becoming extinct and others disappearing locally. Overshoot would pose even greater danger to unique and fragile ecosystems around the world.

In general, ecosystem degradation and biodiversity loss would accelerate globally if 1.5°C is exceeded. Climate stressors for terrestrial, freshwater, and marine ecosystems would increase and multiply, causing additional habitat loss as well as habitat shifts. Biodiversity hotspots, located primarily in developing countries, would come under even greater pressure.

Disrupting ecosystems would also weaken the contributions they make to human well-being (known as ecosystem services), such as coastal protection provided by coral reefs. More species would go extinct. Ultimately, damage to ecosystems would further undermine societal resilience and people's welfare.

Marine ecosystems are also vulnerable. The oceans absorb 25% of CO_2 emissions and 90% of the excess heat from elevated greenhouse gases.[33] The dissolved CO_2 acidifies marine waters. Both acidification and warming harm marine ecosystems. Coral reefs, among the most vulnerable ecosystems, are at risk of being lost even under optimistic scenarios.[34]

Oceans also play an important role in several responses to climate change. Not only do they naturally absorb a large share of emissions, but they can be the site of marine-

based carbon dioxide removal (CDR), such as "blue carbon," and marine cloud brightening, a proposed solar radiation modification (SRM) method – see Sections 7 and 8.

Irreversible and catastrophic changes

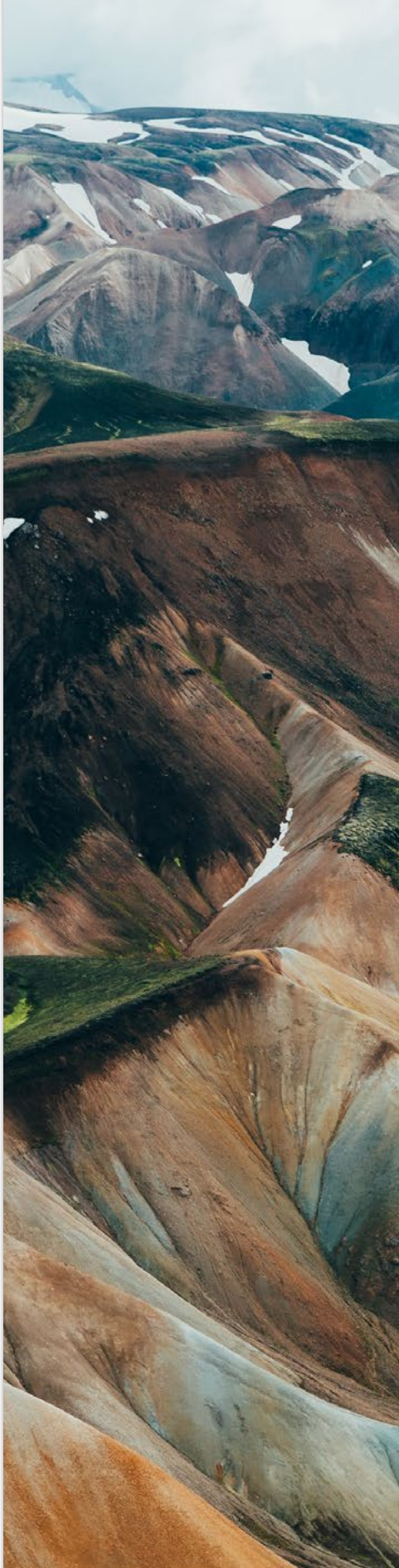
Beyond the risks outlined above, scientists have concluded that several natural systems contain thresholds – sometimes referred to as "tipping points" – which, if crossed, could lead to nonlinear effects that may not be reversible.

Among the most cited examples are the West Antarctic Ice Sheet and similar formations. These are massive reservoirs of frozen water that influence sea level, ocean circulation, and climate. Warming can cause the ice sheets to melt, to calve – creating icebergs – and to collapse. If a critical temperature threshold is crossed, whose exact value is uncertain, they could enter a state of irreversible retreat, leading to meters of sea level rise over centuries or millennia.

Thresholds at some risk of being crossed at less than 2°C of warming include abrupt loss of Barents Sea ice, abrupt thaw of boreal permafrost, collapse of the Labrador Sea/subpolar gyre, low-latitude coral reef die-off, drying of the Amazon to a savannah-like state, and collapse of the Greenland and West Antarctic ice sheets.[35]

The likelihood of crossing such thresholds would increase in proportion to the magnitude of overshoot. Crossing these could have widespread consequences for human and natural systems – unparalleled in modern human history – as well as cascading effects that could be irreversible on human timescales. This means that the changes could not be undone even if warming is reduced or reversed.

While scientists have not established that any global-scale systems have this nonlinear characteristic, crossing multiple thresholds might result in regional effects that, when aggregated, could cause great harm to the entire world.



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CLIMATE OVERSHOOT COMMISSION

REDUCING THE RISKS OF CLIMATE OVERSHOOT

Priority Approaches

03

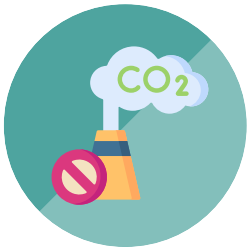
SEPTEMBER 2023

Image credit: Eyoel Kahssay, Unsplash

4. Responses to Possible Climate Overshoot

Key messages

- There is a range of responses to climate change that could both lessen the possibility of overshoot and reduce its magnitude and duration if it happens.
- These responses differ considerably in effectiveness, availability, opportunities, costs, risks, and certainty.
- Cutting emissions remains the priority. Adaptation is necessary to cope with impacts. Carbon dioxide removal from the atmosphere will be needed. Solar radiation modification should be researched, and its governance discussed.



Exceeding 1.5°C would cause serious harm to people and nature everywhere, but would hurt developing countries disproportionately.[36] These impacts would work to slow – and possibly even reverse – development in these countries, which bear the least responsibility for climate change. This fundamental mismatch between responsibility and suffering epitomizes climate injustice.

By the same token, climate action could bring outsize benefits to these countries, providing opportunities for greater prosperity and well-being.

Reducing the likelihood, magnitude, and duration of overshoot, reducing the risks associated with it, and managing risks that cannot be avoided, are thus moral imperatives, as is sharing the opportunities offered by measures to stop an overshoot.

In the current context, no single approach can achieve these aims. Instead, we must rely on a combination of currently and potentially available approaches. These approaches reduce either greenhouse gas concentrations to limit the magnitude and duration of overshoot, or the impacts resulting from overshoot. Because overshoot involves considerable uncertainty, decision-makers pursuing a combination of approaches should exercise precaution, as emphasized by the Climate Overshoot Commission's Youth Engagement Group.

Reduce Emissions

The first and most important approach is to rapidly accelerate reductions of greenhouse gas emissions to stop making the problem worse. None of the other approaches discussed here changes this fact. Deep decarbonization will require much bolder and more innovative action than has been taken up to now, including phasing out fossil fuels and reorienting global climate governance. But the knowledge and

technologies necessary to slash emissions at a faster rate already exist. Turbocharging emissions reductions is the subject of Section 5.

Adapt

Unfortunately, even if we significantly accelerate efforts, it is highly unlikely that emissions cuts alone can prevent further severe harm from climate change. Thus, the second approach is to rapidly expand the implementation of effective adaptation measures. Many tools to enhance resilience have already proved successful, yet adaptation needs to be transformed in both qualitative terms, with novel, forward-looking initiatives, and in quantitative terms, with much greater flows of adaptation finance aligned with the SDGs. (See Section 6.)

Carbon Dioxide Removal

Third, to help slow the growth of the atmospheric stock of CO_2 – and ultimately reduce it – carbon dioxide removal (CDR), also known as greenhouse gas removal or negative emissions technologies, would need to be employed on a massive scale. Some CDR methods store carbon as organic material (such as plants, wood, or soils) and others store inorganic carbon (in the form of minerals, dissolved carbonate, or compressed CO_2 fluids underground). The former methods tend to be currently available and offer co-benefits while the latter have greater removal potential but will not be available at sufficient scale in the near future. Upscaling CDR in the medium term would require policies carefully designed to incentivize higher-quality CDR that promotes co-benefits – such as ecosystem restoration – and ensures permanence, with costs and opportunities distributed fairly (See Section 7.)

Solar Radiation Modification

Lastly, given the magnitude of the impacts expected to result from overshoot, research into solar radiation modification (SRM) should be pursued and governance approaches explored. The uncertainties and risks of such methods necessitate both of these actions. Enhancing knowledge and global discussions about SRM is the subject of Section 8.

Climate Finance

Although climate action often yields net benefits, it entails substantial early financial costs. A policy proposal will usually remain a mere proposal until it is funded. Section 9 thus confronts the overarching question of climate finance.

These approaches will not operate in isolation, but rather would interact with one another, sometimes in complex ways. This requires thinking about their use as integrated components of an overall strategy for reducing and managing the risks of climate overshoot, the topic of the report's conclusion.

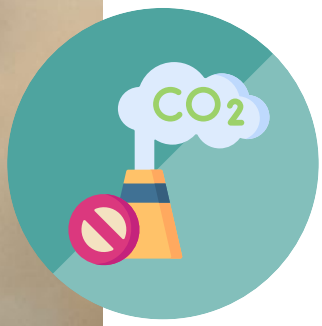
Emissions reductions must be the priority, supplemented by adaptation and carbon removal; all three of these approaches are available now and should be ramped up immediately. SRM is not available now, and may never be. Under no circumstances should it be used today – only research and governance dialogues should take place. Adopting an integrated strategy for governing risks from climate overshoot, privileging available options but also exploring those that are currently unavailable, is the subject of the conclusion of this report.

5. Emissions Reductions

Key messages

- Emissions cuts must come first.
- Because the use of fossil fuels is the primary cause of climate change, fossil fuels should be phased out, through national actions coordinated internationally.
- Industrialized countries need to cut emissions most swiftly (and move towards net negative targets) to give the least industrialized countries more space to reduce poverty and pursue sustainable, low-carbon development.
- Strong international accountability and technology mechanisms are needed to ensure countries keep pace with their promised emissions trajectories.

Image credit: Tim Van Der Kuip, Unsplash



Background

Greenhouse gas emissions from the burning of fossil fuels are the primary cause of climate change,[37] and cutting those emissions is foundational to climate action. To replace fossil fuels and make the transition to clean energy, massive new investments in renewable energy sources and other low- and no-carbon energy technologies will be necessary, enabled by widespread adoption of strong, appropriate policy instruments.

The Climate Overshoot Commission's Youth Engagement Group wrote that "A step change in mitigation action is needed, and current rates of progress need to accelerate dramatically. Any such acceleration should foster a rapid and equitable phase-out of fossil fuel production." Phasing out fossil fuels is a substantial economic, technological and political undertaking, involving vested interests, vastly differing levels of development both between and within countries, as well as historic injustices and responsibilities.

This year's global stocktake of climate action under the Paris Agreement underlines the scale of the challenge. Even though we know what we must do, the world is still not moving nearly fast enough to limit warming to 1.5°C. Unless emissions cuts are dramatically accelerated, we will not achieve this goal.

To cut through the impasse, the Commission believes, it is important for the world to re-establish clarity about its end goals, before settling on the means to accelerate their achievement.

The first piece of clarity lies in how to think about fossil fuels – which are still continuously being promoted by the fossil fuel industry.[38]

Many ways to approach this challenge have been suggested, including emissions phase-out, net zero, and true zero. After consideration, the Commission settled on the objective of a "graduated, differentiated phase-out of fossil fuels."

The Commission believes the world should put the focus firmly back on fossil fuels as the main problem and cut through any ambiguity that other formulations can encourage. At the same time, the Commission emphasizes that phase-out should be graduated and differentiated because different countries and communities face very different situations.

This leads us to the second piece of clarity. The world must recognize that the transition away from fossil fuels will have different implications for developing countries, and that it should be paired with the imperatives of reducing poverty and advancing development. For that reason, the Commission argues that the richest countries need to cut emissions more deeply and more rapidly to give developing countries greater space to undertake their own transition.

For developing countries to undertake their transitions, a more enabling environment is necessary. In particular, this means mobilizing far more finance more quickly, finding innovative ways to facilitate access to low-carbon technologies, and coordinating policy instruments and fora more effectively.

At the same time, "differentiated targets" should not be seen as a blank check. That is why the Commission argues for robust international accountability, which both takes account of countries' different trajectories and holds them to appropriate standards.

Finally, relying on carbon capture and storage (CCS) as an alternative to prompt reduction and phase-out of fossil fuels is not a viable option, although it can contribute to the energy transition in secondary ways. Using CCS to decarbonize the entire energy sector would be technically challenging and hugely expensive,[39] much more so than accelerating the shift to renewables that are available now for most energy uses.

Technical characteristics

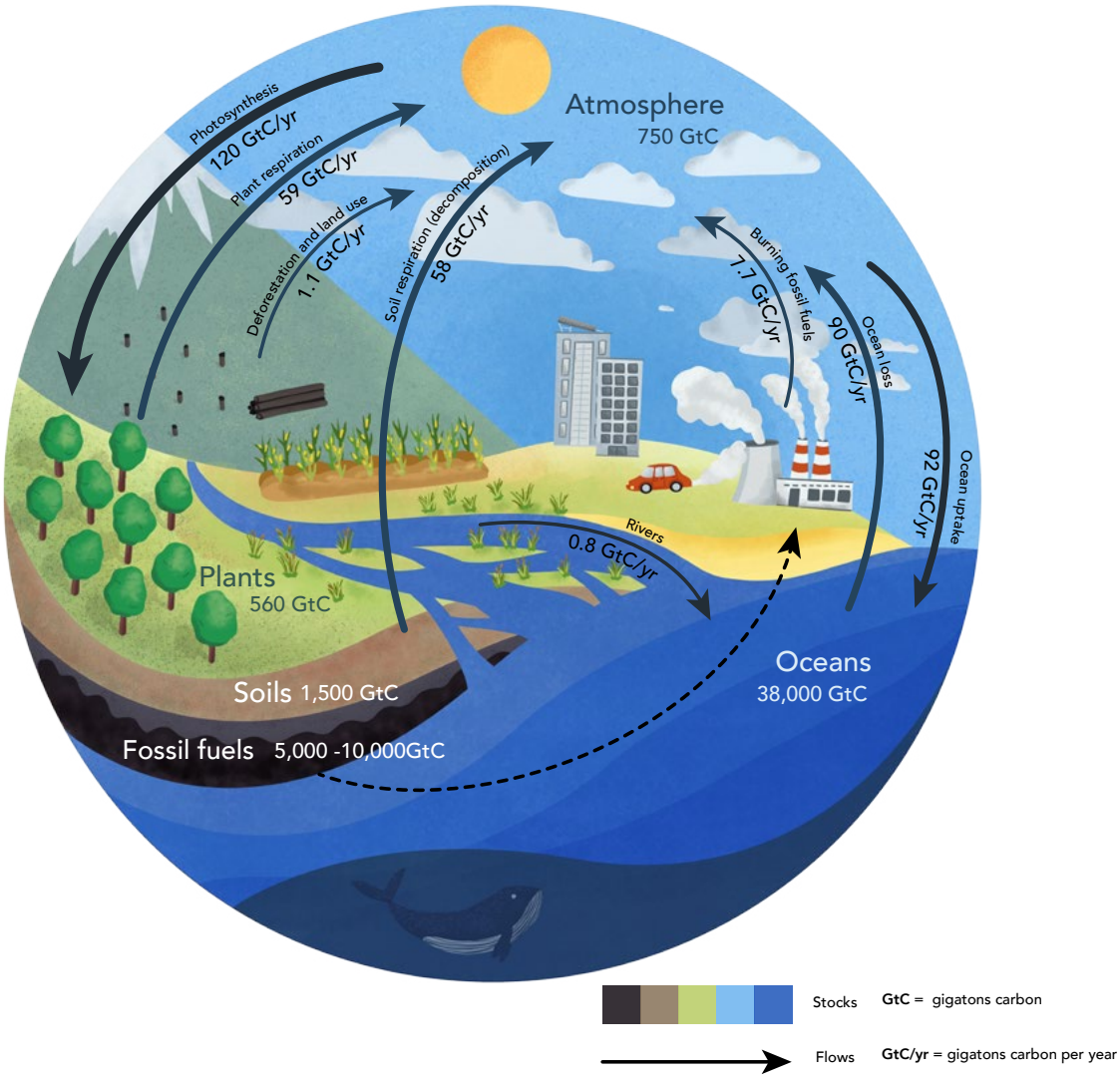
Greenhouse gas emissions derive primarily from burning fossil fuels in the power, industrial, buildings, and transport sectors, as well as from agriculture and land use.[40] (See Figure 4.)

Power plants and industrial facilities represent capital-intensive, long-term investments, so building them without emissions control technologies – which are often expensive – creates decades-long commitments to emissions.

By contrast, the costs of many low-carbon alternatives, including solar and wind energy, have sharply declined in recent years. They are now often cheaper than or at least cost-competitive with emissions-intensive technologies such as coal-fired power plants. Taking advantage of such developments may involve additional challenges, but in most cases solutions are available. For example, since renewables are intermittent sources of energy, integrating them into the power grid requires that they be accompanied by reliable, flexible baseload generation.

Emissions from land-use change are much smaller at a global level.[42] However, they are the leading emissions source for some developing countries. Most land-use change emissions come from deforestation, and most deforestation occurs in the tropics.[43] Deforestation not only releases CO_2 into the atmosphere but also destroys habitats, biodiversity, and ecosystem services.

FIGURE 4 The carbon cycle.[41]



Effective approaches to stopping deforestation include minimizing road intrusions into forested areas, establishing and securing protected areas, providing payments for ecosystem services, and working with the agriculture sector to promote conservation. Afforestation and reforestation can enhance carbon sequestration, locking carbon into plants and soils, as well as provide other benefits such as soil conservation, water regulation, and wildlife protection. (See Section 7.)

Other greenhouse gases and pollutants also contribute to climate change. Unlike CO_2, some of these remain in the atmosphere for relatively short periods of time – days to decades. As a consequence, cutting their emissions would quickly reduce their contribution to global warming. Such "short-lived climate pollutants" – which include methane, ground-level ozone, and black carbon – offer an opportunity for action with short-term climatic benefits.[44]

Governance challenges

Boosting emissions cuts requires tackling four main governance hurdles: raising ambition, strengthening accountability, clarifying responsibilities, and providing enabling mechanisms.

First, emissions must be aggressively cut in the short, medium, and long term, and public commitments to ambitious goals and targets are needed to maintain a dynamic pace. Based on current NDCs, the world is expected to warm by 2.6°C above pre-industrial levels by the end of the century. (See Figure 3.) Efforts to raise ambition face several obstacles. Countries' levels of development, emissions, and capabilities – historical and evolving – should be considered in global efforts. To improve coherence and effectiveness, NDCs should be reconciled with goals and targets defined by subnational governments, sectors, companies, and other actors. A wide range of policy instruments, including carbon pricing, taxation, regulation, subsidies, infrastructure investment, education, and innovation policies, can be used to pursue more aggressive emissions cuts.

Second, public pledges to pursue more ambitious goals and targets will be insufficient to achieve significant cuts in emissions without strong accountability mechanisms. Under the Paris Agreement, the primary mechanism for providing accountability is the "enhanced transparency framework." The framework does not review NDCs themselves, however, which parties are free to formulate as they see fit.

Third, since its creation, the principle of "common but differentiated responsibilities," according to which developed countries bear primary responsibility for addressing climate change, has been central to the functioning

Image credit: Antonio Garcia, Unsplash

of international climate governance. The energy transition will be costly, and developing countries have fewer resources available to carry it out. In addition, their need to promote economic development and reduce poverty only partly overlaps with the need to decarbonize.

Fourth, given the capacity constraints of developing countries, several enabling mechanisms have been set up to help them cut emissions and meet their climate commitments. For example, the Climate Technology Centre and Network provides technical assistance and capacity-building to developing countries to promote diffusion of climate technologies to accelerate their energy transitions.

Technology transfer depends on climate finance. Most financial assistance is delivered through multilateral development banks, with a smaller amount provided by dedicated climate funds. Developing countries need more technology, more finance, and effective policy frameworks to ensure the technology is moved to market.

More broadly, an enabling environment at the international level is necessary to facilitate the achievement of more ambitious emissions reduction goals by all countries. For example, national climate policies have trade implications. Insufficient clarity on the comparability and compatibility of different national policies will generate trade frictions, which may impede the pursuit of more aggressive emissions reductions at the national level. Putting a price on carbon in one jurisdiction may lead to carbon leakage – when businesses transfer production to jurisdictions with laxer emission constraints – or put local producers at a disadvantage compared with producers elsewhere who are not subject to such a price.

Efforts to tackle these problems, such as the proposed Carbon Border Adjustment Mechanism of the European Union, could exacerbate trade frictions with other trading partners. Alternatively, clean energy tax credits such as those provided by the US Inflation Reduction Act may put ineligible foreign producers at a competitive disadvantage, leading to trade tensions.

Recommendations

Deep and rapid decarbonization of the world economy will require bold, even radical action on multiple fronts, far beyond existing efforts. To this end, the Commission recommends three core strategies:

01 **First, governments should decide on a phase-out in production and consumption of all fossil fuels and accelerate their trajectories to this end, while broadening and deepening international discussions on this agenda.**[45]

The need for such a phase-out is now clear, although there is still resistance to it.

To ensure justice and equity, reductions should be differentiated according to countries' needs and levels of development. Industrialized countries, with large capacities to accelerate investment in clean energy, should first cap production and consumption of fossil fuels at current levels. This might be implemented by ceasing approval of new production facilities and large power plants, which would cause most investments in fossil fuels to end.

Phased reductions of production and consumption (including subsidies) would follow. These reductions should have a timeline long enough to provide confidence of technical feasibility, including for replacements, while limiting energy market disruption and the stranding of assets, which occurs when resources such as coal-fired power plants are retired before the end of their economic life. (Importantly, governments should not cover the costs of such stranded assets.)

As phase-outs approach zero, essential-use exemptions should be provided for the hardest sectors to abate. The phase-out should be accompanied by policy and financial measures, including public funding, to ensure just transitions for displaced workers and impacted communities.

Fossil fuel phase-out may begin with a small club of countries but should ultimately – and quickly – be global in scope. If phase-out begins with a club of countries, imports of fossil fuels and closely related products that are produced in non-participating jurisdictions should be progressively restricted. The Beyond Oil and Gas Alliance, a multi-country coalition on phasing out fossil fuels launched at COP26 in Glasgow in 2021, could be enlarged. Phase-out also has to include companies that commit, with third party verification, to absolute reductions of direct and energy-related emissions as well as ambitious targets for investments in renewables. When a critical mass of countries is achieved, governments could initiate discussions to consider an international legal instrument, fully compatible with the Paris Agreement, that would institutionalize and strengthen a graduated, differentiated phaseout of fossil fuels.

To replace fossil fuels, the international community should simultaneously redouble its commitment to renewables by pursuing a global green power target. The International Renewable Energy Agency (IRENA) has called for the world to add 1,000 gigawatts of renewable energy capacity annually by 2030.[46] The Commission supports this goal and efforts by IRENA and others to gain global agreement on such a target. Renewables must ultimately replace fossil fuels, and a global goal can help focus attention and galvanize action to accelerate the transition to clean energy.

To supplement a fossil fuel phase-out, efforts to control short-lived climate pollutants should be boosted substantially, to reduce near-term warming and improve public health. Measures to reduce emissions of some hydrofluorocarbons, methane, and black carbon, including the Kigali Amendment to the Montreal Protocol and the Global Methane Challenge, should be strongly supported including through policy frameworks. Methane reduction options that should be promoted include methane fees, feed additives for livestock, upgrading pipelines, and capturing methane from extractive and agricultural activities.

02 **Second, the world should recognize that developing countries will face particular challenges, and the global energy transition should be paired with imperatives of poverty reduction and development.** Therefore, to bolster equity, differentiated roles based on countries' development status should be articulated more clearly and forcefully. For the least industrialized countries, transition trajectories might entail, for example, expanded access to affordable and reliable energy to help alleviate poverty, or replacing traditional biomass cookstoves with liquefied petroleum gas.

At the same time, the richest countries, including the oil exporting countries, need to reduce emissions faster to give less developed countries more space to undertake their own transitions. Richer countries should aim not just for net-zero emissions by 2050 but for net-negative emissions, meaning that they remove more CO2 from the atmosphere than they emit, to compensate for the later net-zero targets of low- and middle-income countries. Such an effort could be initiated by the Organisation for Economic Co-operation and Development or the Group of Seven.

03 Third, achieving an energy transition that meets the different needs of different countries requires ensuring that key facilitative conditions are met. These include greater accountability, sharing of technology and mutual recognition of national climate measures affecting trade.

Accountability systems should be strengthened to make available reliable and relevant information on the impacts and risks of public and private sector activities. Accountability takes several forms: national strategies that transparently set intermediate targets and indicators for different sectors and activities; public evaluation that involves external independent assessment; regular national reporting and comparison in multilateral fora; and national processes that provide relevant and timely information on progress and performance. For the public sector, the International Public Sector Accounting Standards Board is developing a sustainability reporting framework to enhance transparency and accountability. This will enable public sector entities to disclose their climate-related goals, plans and performance consistently and comparably.[47] Accountability from subnational and private actors should also be strengthened, following guidance from the UN Secretary-General's High-level Expert Group on Net-Zero Commitments, which has issued a report with recommendations to ensure credible, accountable and transparent net-zero pledges by non-state actors.[48]

In addition, international mechanisms should be established to accelerate the deployment of new technologies necessary to the energy transition and ensure worldwide access to them. Mechanisms to acquire and release patents when the need is demonstrated – making them available for free – could be modelled on practices pioneered by non-commercial patent pools such as the Eco-Patent Commons, Golden Rice, the Medicines Patent Pool, and the World Intellectual Property Organization's Re:Search facility. This could be supplemented with public and private finance and capacity-building. Additionally, specific financial support mechanisms should be explored for assisting low- and middle-income countries in cases where importing climate technologies adds to an unsustainable current account deficit.

Furthermore, mutual recognition of national climate policies should be promoted, and attention should be given to the impact of climate-related trade measures in cases where they negatively affect the exports of poorer developing countries. To reduce potential for trade conflicts that would stand in the way of more ambitious emissions cuts, the World Trade Organization could work to enable mutual recognition of different national climate measures affecting trade. The first step would consist of creating a "comparability forum" to agree on a common metric for climate measures. Once a metric is established and national climate policies can be assessed in comparable terms, this body could be succeeded by a "compatibility forum" in which states recognize one another's policies as mutually compatible. In parallel, specific technical assistance facilities must be made available to developing countries to help them build the necessary capacities to avoid trade-related harm stemming from the climate policies of high-income countries.

6. Adaptation

Key messages

- To cope with the impacts of climate change, adaptation is necessary at a much larger scale.
- For adaptation to succeed in the long term requires reducing emissions.
- New tools and mechanisms should be created, such as country-level partnerships for adaptation and robust metrics for assessing adaptation strategies.
- Supporting adaptation interventions in agriculture is particularly critical, given its importance in poor countries.
- Significantly more climate finance is necessary to support adaptation activities, especially in developing countries.

Image credit: Thomas Richter, Unsplash

Background

Even at today's average global warming level of 1.2°C, vulnerable people and ecosystems around the world are suffering. This distress will only intensify as temperatures continue to rise.

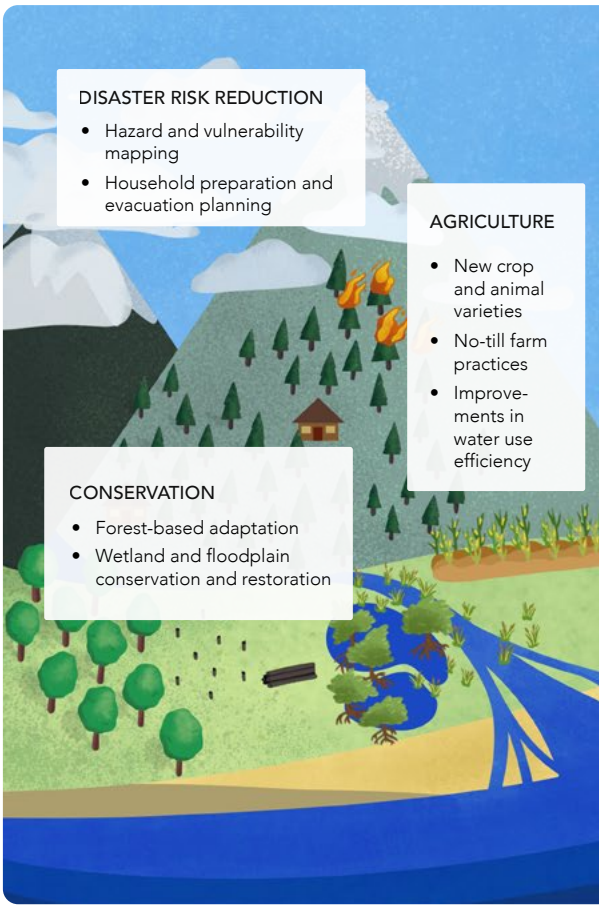
Enhanced adaptation is an urgent moral and economic imperative to protect billions of vulnerable people from the droughts, famines, floods and other harms caused by a changing climate, as well as to offer them greater economic opportunities. This agenda cannot wait, given the magnitude of impacts being felt right now.

The Global Goal on Adaptation[49] needs to be given teeth, accompanied by a massive scale-up of financing. It should be built around a common framework that focuses laser-like on hyperlocal needs, driven by data and evidence, in the service of broader sustainable development. Indeed, adaptation is integral to meeting the SDGs.

Emissions reductions and adaptation are not equivalent and should not be treated as such. The former addresses the causes of the problem – the growing stock of CO_2 in the atmosphere – while adaptation addresses some of its impacts. If temperatures continue to rise unabated, adaptation will be a losing battle because climate disruption will outpace response actions. Conversely, even when emissions are finally down to zero, adaptation will still be necessary.

Rising temperatures change risk patterns. While our societies were relatively adapted to a climate close to pre-industrial levels, at warming of 1.2°C we already need to make changes to adapt to different risks; there will be further changes to make if we reach 1.5°C; and still more if warming reaches 2°C.

FIGURE 5 **Adaptation measures.**



Adaptation can take many forms, including (see Figure 5):

- ☑ structural interventions such as building sea walls or irrigation systems,
- ☑ institutional reforms such as strengthening disaster risk management or social protection systems,
- ☑ behavioural and technological changes such as adopting drought-resistant crops or relocating to safer areas,
- ☑ conserving certain natural ecosystems.

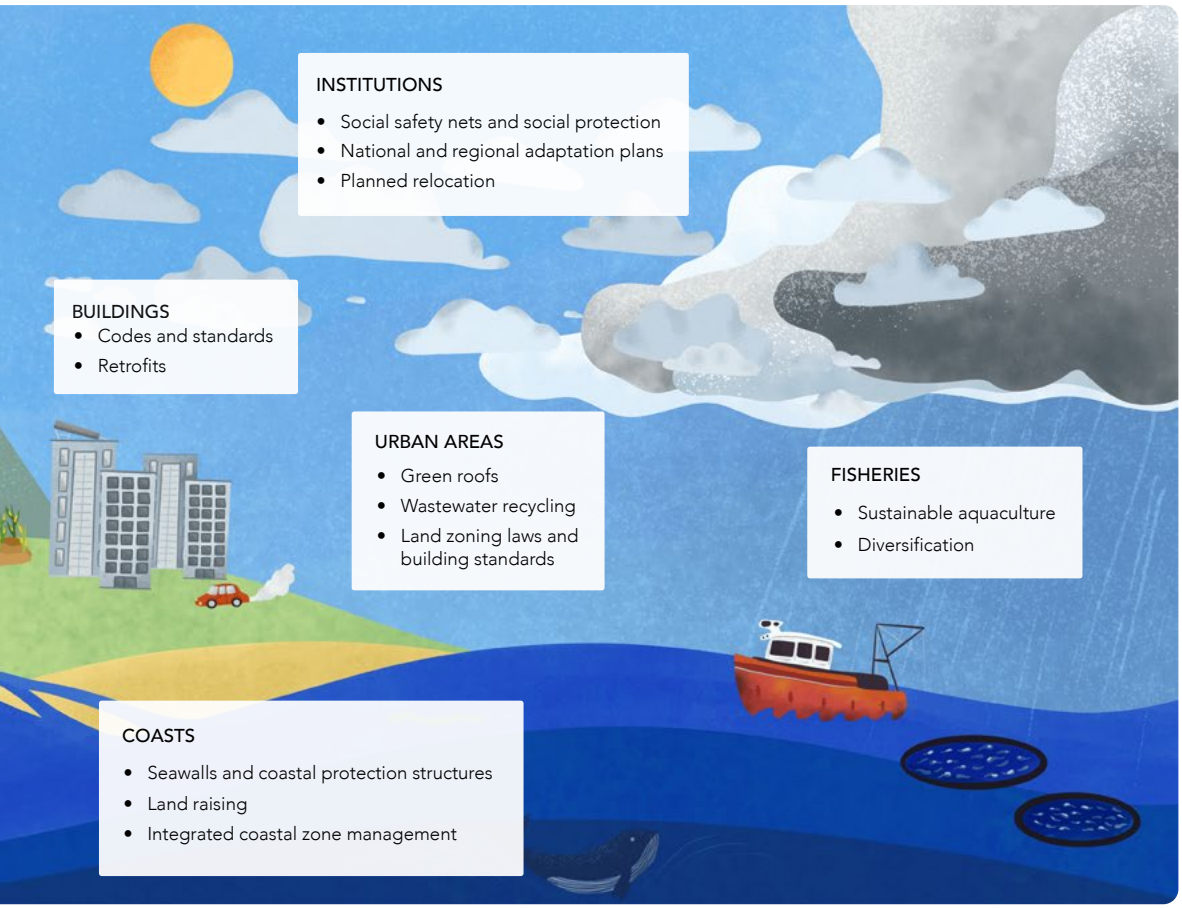
Adaptation efforts to address climate mobility including climate migration and refugees, are of urgent concern to small island developing states and others.

Some adaptation measures are reactive, responding to observed or experienced impacts; others are anticipatory, preparing for projected or potential impacts. Some are incremental, adjusting to moderate changes; others are transformational, altering the fundamental attributes of a system. Some adaptation measures can provide multiple benefits, such as enhancing resilience, reducing poverty, improving health, boosting agriculture, or restoring ecosystems.

All adaptation measures require financial resources on a far greater scale than they are receiving today, especially in developing countries suffering from intensifying economic challenges.

Not only are adaptation efforts a moral duty, but they also carry economic benefits. As estimated by the Global Commission on Adaptation, building climate-resilient infrastructure can generate returns that outweigh costs by a factor of four.

Adaptation also entails trade-offs, however. For example, nature-based measures such as afforestation or wetland restoration can provide carbon sequestration, biodiversity conservation, and water regulation services,



but they may also compete with other land uses such as agriculture or urbanization. These trade-offs should be identified, assessed, and managed through participatory and accountable processes that involve all relevant stakeholders; approaches like climate-smart agriculture may be helpful in managing such trade-offs. The causes and symptoms of climate change can be addressed hand in hand, but considerably more resources are needed if we are to do so.

Adaptation is often treated as a separate issue from development rather than being integrated into broader policies and plans. Key questions addressed by the Climate Overshoot Commission include how to mainstream adaptation into broader development strategies (without creating a zero-sum game), how this should be paid for (and by whom), and what transformative adaptation actions could be undertaken to limit the risks from climate overshoot, taking account of local needs and conditions.

The Commission does not have answers to the many questions that accompany this work but has settled on recommendations and guiding principles to help high-level policy makers more effectively direct their efforts.

Technical characteristics

Adaptation needs vary widely across regions and countries, depending on their exposure and vulnerability to climate hazards, their development status and priorities, and their adaptive capacity and resources. There is no one-size-fits-all solution. Adaptation requires context-specific, participatory, and inclusive approaches that respond to the needs and preferences of different groups and sectors.

Adaptation to climate change consists of adjusting and building resilience to current and future climate change, for both people and nature. Adaptation will reduce some harm from overshoot, but as warming intensifies, it will become both more important and more difficult to provide; there are physical as well as sociopolitical (for example, financial) limits to adaptation.[51] "Maladaptation" occurs when adaptation measures unintentionally increase risk and vulnerability. For example, using air conditioning to cope with higher temperatures, if it is powered by electricity generated from fossil fuels, would result in more emissions and greater warming.

Adaptation needs and capacity vary widely. Most adaptation involves local actions targeting local benefits. Because many adaptation actions are costly or politically difficult, adaptation is often inadequate. Adaptation shortfalls are universal but are especially consequential for developing countries, which are facing the most severe climate impacts. In regions such as Sub-Saharan Africa, the gap between adaptation needs and available resources is huge and continuing to grow.

Adaptation, and in particular adaptation finance, is frequently considered in the context of the pledge made by developed countries at the 2009 UN climate summit in Copenhagen and formalized at the 2010 climate summit in Cancún, to provide developing countries with 100 billion USD annually in climate finance (for emissions reductions and adaptation) by 2020,[52] a pledge that is both insufficient and was met only recently.[53] (See Section 9.)

Adaptation measures vary widely in terms of sector, location, type of action, timing, and feasibility. Examples include:

- seawalls and coastal protection structures;
- new crop and animal varieties;
- forest-based adaptation;
- improvements in water use efficiency;
- wetland and floodplain conservation and restoration;
- social safety nets and social protection;
- hazard and vulnerability mapping;
- household preparation and evacuation planning;
- land zoning laws and building standards;
- national and regional adaptation plans;
- and, at the extreme, planned relocation.

Protection from heat-related human health threats is particularly urgent.

The highly context-specific nature of adaptation has hindered efforts to develop standard metrics for assessing the effectiveness of adaptation options.[54] Metrics are an important tool to monitor outcomes at different levels, evaluate options and identify best

practices, and improve planning and decision making. Without them, it is difficult to know what works and what does not. Efforts to develop adaptation metrics, for example by the International Platform on Adaptation Metrics and the Green Climate Fund, are only at an early stage. This lack of metrics has, in turn, complicated efforts to develop broad strategies and prioritize specific measures.[55] To succeed, such efforts will require much more data on adaptation measures and activities, as well as additional resources. Innovative data collection methods, including remote sensing and the use of digital networks, may help address these needs.

Governance challenges

Adaptation poses several governance challenges at different levels and scales. At the global level, it needs more political attention and financial support. The Paris Agreement established a Global Goal on Adaptation, which aims to enhance adaptive capacity, strengthen resilience, and reduce vulnerability. However, this goal is neither legally binding nor quantifiable, unlike the collective emissions goal. Moreover, the adaptation finance gap remains large and persistent. According to UNEP, the annual cost of adaptation in developing countries could range from 140 to 300 billion USD by 2030, and from 280 to 500 billion USD by 2050.[56]

The lack of adaptation metrics makes it more difficult to mobilize finance for adaptation, but it is not the cause of shortfalls in such finance.[57] Rather, the reason for such shortfalls is the continued unwillingness of developed countries to invest significant resources in adaptation in developing countries. Adaptation financing requirements are five to ten times greater than current international public adaptation finance flows.[58] These needs relate primarily to agriculture, forestry, ecosystems, water, and energy. The vast bulk of multilateral adaptation finance – roughly 95 percent in 2020-2021 – currently moves through multilateral development banks.[59] The remainder flows through dedicated multilateral climate funds including the Green Climate Fund, Adaptation Fund, Least Developed Countries Fund, and Special Climate Change Fund. Private finance is unlikely to fill the gap in these and other sectors, because returns on adaptation investments with public goods qualities are either small or difficult to capture.[60] (See Section 9.)

At the national level, governments need to bring adaptation into the mainstream of broader development policies and plans, and coordinate adaptation action across different sectors and levels of government.[61] The benefits of mainstreaming include improved development results and enhanced efficiency and scale of adaptation finance flows. Governments also need to strengthen the institutional and legal frameworks that enable effective planning, implementation, monitoring, and evaluation of adaptation actions.

At the local level, the specific needs and preferences of different groups and sectors need to be addressed, taking into account their exposure and vulnerability to climate hazards, their development priorities and aspirations, and their adaptive capacity and resources. It is crucial to respect the rights and interests of everyone involved in adaptation, especially those who are marginalized or disadvantaged. Adaptation also requires fostering social learning and innovation, building on traditional knowledge

and practices, and promoting behavioural change and empowerment.

Specific attention to agriculture and agrifood systems is vital for the livelihoods and food security of millions of people in developing countries, especially in sub-Saharan Africa. These systems are highly vulnerable to the impacts of climate change, such as rising temperatures, droughts, floods, pests and diseases. By 2050, nearly 80 percent of small farms in India, Ethiopia, and Mexico may be experiencing climate impacts.[62] Enhancing the resilience and adaptation of agriculture and agrifood systems to climate change is a key priority for sustainable development and poverty reduction.

Specific attention to climate mobility is also essential. For some vulnerable communities, for example in low-lying island countries, climate change poses a truly existential threat – sea level rise threatens to submerge entire islands. (See Box 1.) Residents may have no choice but to move elsewhere. Adaptation can help forestall such eventualities and help manage them smoothly and humanely if they come to pass.

Shortfalls in adaptation finance, combined with the view that measures that do receive funding are incremental and insufficient, have led to growing calls to embrace "transformative" adaptation, which would address the root causes of vulnerability by shifting entire socioeconomic systems towards long-term sustainability.[64]

The international community needs to tackle several key governance challenges related to adaptation. First and foremost, the yawning gap between global adaptation needs and what is being provided must be narrowed. Second, planning for adaptation must be more coherent and more strategic, taking explicit account of limits to adaptation and seeking to avoid maladaptation. Finally, adaptation must be fully integrated into efforts to promote sustainable development – including meeting the SDGs – as an essential component of clean, inclusive, and equitable transition pathways.

Box 1: Existential risks to small island states

The most recent assessment report of the IPCC concluded that "In the absence of ambitious human intervention to reduce emissions, climate change impacts are likely to make some small islands uninhabitable in the second part of the 21st century."[63] This is an existential risk, and these states' entire populations will be displaced. Such a threat can be addressed only by the extreme response of wholesale migration. For small islands, climate change impacts have now reached dangerous levels. This is a consequence of the developed world not acting in time.

Yet the international community – especially major emitters – has been reluctant even to use the term "climate refugees," much less begin a dialogue on it. Given that it took three decades for the concept of loss and damage to move from the margins of the UNFCCC to the establishment of a (still empty) fund, these difficult but necessary deliberations are overdue.

Image credit: Karsten Winegart, Unsplash

Recommendations

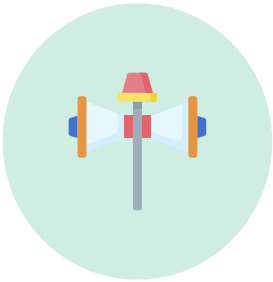
The Commission recommends the following initiatives related to adaptation.

01 **First, because adaptation actions are primarily local in nature, international finance and policy support should be informed by a hyperlocal assessment of climate risks and adaptation priorities.** This assessment should take advantage of granular data on the exposure and vulnerability of districts and communities to different climate hazards. A Global Climate Vulnerability Index would enable the design and delivery of effective and customized adaptation measures that meet each region's particular needs and preferences. It should also enable the development of new digital tools that can help governments, funders, implementing agencies and others to plan and carry out adaptation actions.

02 **Second, to complement and support these assessments, standard metrics for adaptation should be developed.** The development and application of a robust system of standard adaptation metrics will enable more strategic investments in climate resilience. The Commission endorses and supports further work to develop metrics for adaptation effectiveness through such efforts as the International Platform on Adaptation Metrics and its Adaptation Metrics Mapping Evaluation framework project.

03 **Third, to integrate these assessments and priorities into comprehensive action plans, the Just Energy Transition Partnership (JET-P) model – a country-led investment platform geared toward emissions reductions – should be replicated and reconfigured to support adaptation.** A JET-P for adaptation would be based on a long-term, national-level strategy informed by national priorities, supported by international funding commitments, and complemented by a framework for disbursing and monitoring the investments. It would shift adaptation from a project to a national orientation, would facilitate the development of robust National Adaptation Plans, and would involve a broader range of interested parties than is typically engaged in adaptation planning and decision-making. This in turn would facilitate alignment with national development and energy transition plans.

04 **Fourth, to strengthen the response capacity of these plans, global efforts to achieve "Early Warnings for All" should be supported.** Early warning systems protect against extreme weather events, such as floods, droughts, heat waves, and storms. Multi-hazard early warning systems – built on disaster risk knowledge, observations and forecasting, dissemination and communication, and preparedness and response – are critical tools for adapting to climate change and reducing disaster risk. One approach would be to boost support for the UN Early Warnings for All initiative, led by the World Meteorological Organization (WMO), the goal of which is to ensure that every person is protected by early warning systems – including at the local level – by 2027.[65] Early warning systems should be tied to frameworks for emergency response.


05 **Fifth, support should be boosted for efforts to address climate mobility – including migration, displacement, and planned relocation, driven by both slow-onset and extreme weather events.** Most climate mobility will be within countries and major urban areas will figure prominently as in-migration hotspots.[66] Municipal and national governments should be empowered to assist and absorb climate migrants, including through insurance mechanisms and social protection measures. International funds need to adjust their operating mechanisms to include municipalities as eligible implementation partners. They also need to provide funding directly to cities by establishing new dedicated mechanisms and/or expanding the thematic focus of existing ones, such as the Global Cities Fund and International Municipal Investment Fund.

International climate migration, including from small island developing states, warrants particular attention among countries and relevant intergovernmental organizations. The "Migration with Dignity" framework should serve to organize action on climate migration.[67] In addition, the emerging doctrine of "preventing, minimizing, and addressing" climate migration should be elaborated and strengthened, including with new funding and legal arrangements to support the rights of climate migrants. New funding arrangements for loss and damage could finance these and other initiatives tied to climate mobility.

06 **Sixth, given the importance of agriculture and agrifood systems for adaptation to climate change in poor countries, supporting interventions that enhance their resilience is particularly critical.** The Alliance for a Green Revolution in Africa, for example, is an African-led initiative that strengthens smallholder agriculture through improved seeds, soils, markets and policies. More agricultural adaptation is needed across several dimensions. These include:

- promoting practices that conserve and enrich the soil;
- developing more diverse crops that can withstand increased drought, heat, pests, and salinity;
- helping farmers access inputs, finance, information, insurance, and value chains that can increase their income and reduce their vulnerability; and
- using water resources more efficiently and sustainably.

Research on these and other measures, exemplified by work conducted by the Consortium of International Agricultural Research Centers (CGIAR), is also needed to help poor countries cope with climate change while improving food security and livelihoods.

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38 Rich, Nathaniel. 2019. *Losing Earth: A Recent History.* Macmillan, New York.

39 IPCC AR6 WG3, pp. 641-643.

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CLIMATE OVERSHOOT COMMISSION

REDUCING THE RISKS OF CLIMATE OVERSHOOT

Emerging Approaches

04

SEPTEMBER 2023

7. Carbon Dioxide Removal

Key messages

- While cutting emissions is the priority, removing carbon dioxide from the atmosphere at significant scale will be necessary to avoid or limit overshoot.
- One way to categorize carbon dioxide removal methods is according to whether the carbon is stored as organic or inorganic material. These methods differ in terms of their risks, challenges, and opportunities.
- Biological carbon dioxide removal methods should aim at maximizing the co-benefits of these approaches while minimizing the risk that carbon stored is re-released to the atmosphere.
- Methods that store carbon underground or in the oceans should aim at maximizing secure storage while minimizing possible negative effects on people and ecosystems.
- Governance and government support is needed to define and help finance the roll-out of high-integrity carbon removal methods.

Image credit: PIxabar

Background

While cutting emissions by replacing fossil fuels with cleaner energy sources must be the primary strategy to tackle climate change, the problem remains of accumulated carbon emissions already in the atmosphere.

Unless we remove these stocks of CO_2, the best we can do is stop additional global warming beyond whatever heating has been caused by prior emissions. If we exceed average global warming of 1.5°C, then CDR will be required to bring temperatures back down.

In addition, since emissions will not drop to zero immediately, CDR is needed to slow the growth of atmospheric concentrations of CO_2 during the transition.

CDR poses many challenges – as well as potential opportunities. The first set concerns the uncertainty, costs and trade-offs surrounding the various approaches proposed to remove and store atmospheric CO_2, some of which remain immature or untested. The Climate Overshoot Commission's Youth Engagement Group wrote that "we should not assume without evidence that CDR technologies and methods have carbon removal potential on the scale required to make a significant difference to global warming." The Commission agrees that decision-makers must be aware of and cautious regarding assumptions of future technological developments.

The second major challenge is to build governance mechanisms that promote high-integrity carbon removal that is equitable and just, provides broadly shared economic dividends, and in no way undermines or detracts from the primary goal of phasing out fossil fuels. CDR cannot be used as an alternative to emissions cuts and cannot be relied on alone to avoid overshoot.

A third set of challenges concern who should pay for and finance carbon removal, and who should benefit

from the opportunities it could offer. Most IPCC emissions pathways that limit warming to 1.5°C or even 2°C assume scaling up carbon removal to the size of today's fossil fuel industry in the span of a few decades, and with mostly public funding.

Such an expansion would entail one of the more ambitious collective public endeavours in human history, and it is far from clear how it would be paid for. Currently, international carbon markets are neither extensive nor well-controlled enough to provide the necessary incentives. They will require substantial changes, including linking compliance markets and regulating voluntary markets more effectively.

Governments, private businesses and civil society are all struggling with these questions right now, even as the carbon removal sector shows signs of rapid acceleration, and the conclusions they reach will likely have consequences for decades.

The Commission cannot provide answers to all these questions – including the economic challenges and opportunities of scaling up CDR. Rather, it aims to lay out certain key principles that can guide others as they craft policy and allocate resources.

In particular, the Commission focused on the governance gaps remaining to ensure safe and equitable scale-up of CDR, the issue of who should pay, and the need to promote a variety of approaches.

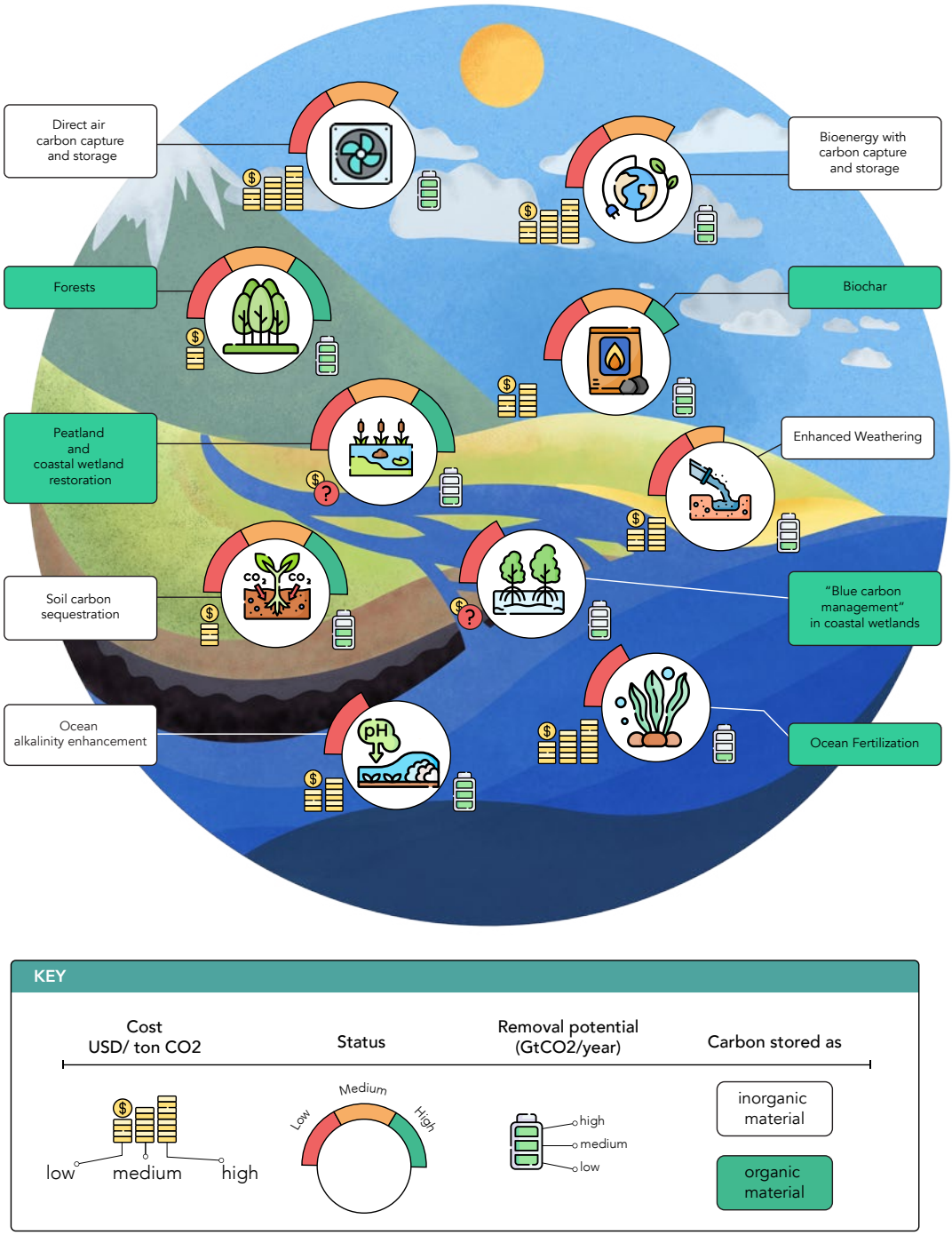
Technical characteristics

CDR refers to a set of technologies and practices that remove CO_2 from the atmosphere and store it for periods ranging from years to millennia. CDR is not the same as CCS, which aims to capture carbon pollution at point sources (such as power plants) to *avoid CO_2 emissions*, rather than *remove CO_2 from the ambient air*.

CDR could be used to remove excess atmospheric CO_2 at a faster rate than would naturally occur, but significantly reducing atmospheric CO_2 concentrations and associated climate risks will require CDR at large scale and means to store CO_2 securely and reliably. The IPCC has concluded that CDR is an "essential element" of net emissions scenarios that would likely limit warming to 1.5°C or below 2°C.[68] CDR would also allow for offsetting hard-to-abate emissions from activities like steel production and rice cultivation (although innovation could change what qualifies as "hard-to-abate" over time). Carbon removal is slow to act, and the types of CDR with the largest potential are more expensive than most emissions cuts. Risks associated with CDR tend to be local in nature but vary according to method.

One way to categorize CDR methods is according to whether the carbon is stored as organic or inorganic material. (See Figure 6.) Biological CDR techniques that store organic carbon rely on the uptake of CO_2 by plants to remove carbon from the atmosphere and store it in materials such as wood, soils, and marine sediments. Some of these methods involve intensive agro-industrial processes such as biochar or no-till farming. Methods that restore degraded environments such as ecosystem restoration, reforestation, no-till farming, and enhancement of wetlands, if implemented properly, offer ecological benefits and improvements in agricultural productivity that are separate from and additional to carbon removal.[70] Methods based on organic carbon storage are relatively mature and can be implemented today. An example is Africa's Great Green Wall. (See Box 2.) Biological CDR methods have much in common and substantially overlap with nature-based solutions. (See Box 3.)

FIGURE 6 Carbon dioxide removal methods.[69]



Box 2: The Great Green Wall

The Great Green Wall of Africa is an ambitious, large-scale land restoration project spanning 7,000 kilometres from Senegal to Djibouti. The African Union initiated the project in 2007 to combat the drought and desertification that affects around 45% of the continent's land area by restoring degraded land and planting trees and other vegetation. However, the project will also make a significant contribution to tackling climate change, aiming to capture 250 million tonnes of CO2 as well as preserve biodiversity, enhance food security, and bolster resilience.

The Great Green Wall project seeks to rehabilitate 1 million square kilometres by 2030, which is expected to create 10 million jobs. To date, 11 countries have contributed to its progress, rehabilitating 40,000 square kilometres. A broader group of 21 African countries is committed to achieving its goals.

Financing is essential. Governments need to secure 4 billion USD annually for the next decade to make this vision a reality. Ultimate success will require not only significant financial resources but also improved regional coordination among governments and subnational communities; attention to potential synergies and trade-offs; and an adaptive, integrative management approach.

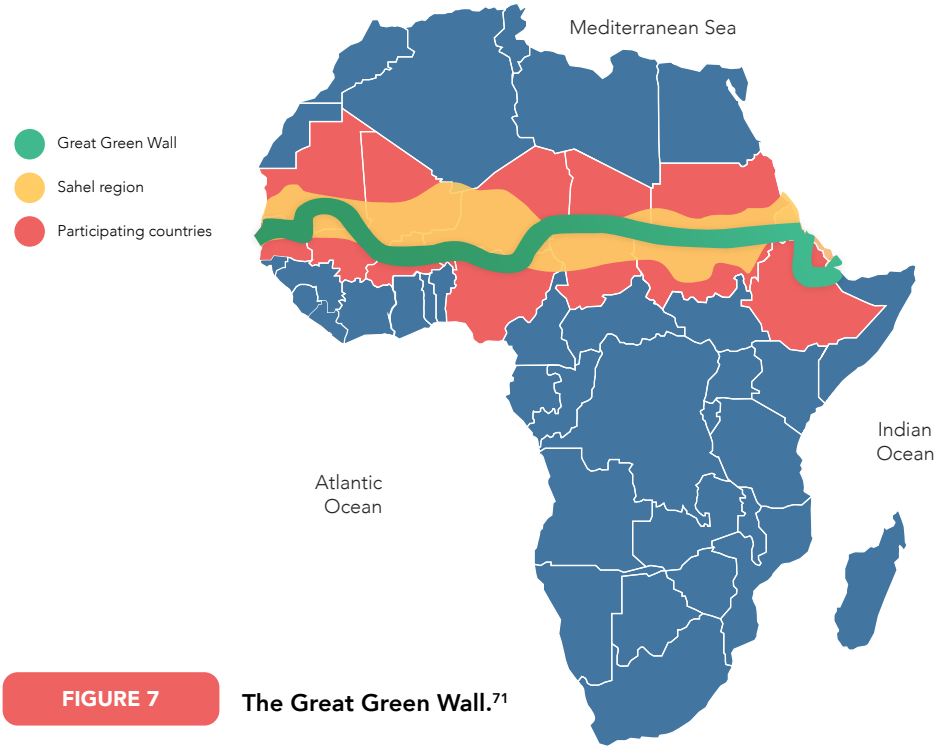


FIGURE 7 **The Great Green Wall.**[71]

Box 3: Nature-based solutions

Nature-based solutions (NBS) focus on how protecting and restoring natural environments can generate societal benefits including sustainable development, climate action, strengthened agriculture, and biodiversity conservation. Recently, the UN Environment Assembly (UNEA) formally defined NBS as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits."[72]

A distinctive feature of NBS is that they can be designed to address multiple challenges, including multiple aspects of climate change.[73] Some climate-relevant NBS address adaptation by bolstering resilience against climate impacts; these are often referred to as ecosystem-based adaptation measures. Some climate NBS remove CO2 from the atmosphere. Some do both. Because NBS perform multiple functions, they may be subject to competing uses.

NBS are widely supported, such as through the Montreal-Kunming Global Biodiversity Framework of the UN Convention on Biological Diversity, which calls for mobilizing 700 billion USD per year by 2030 from public and private sources, domestic and international, for biodiversity finance, including for NBS. Other initiatives such as the Positive Conservation Partnerships, launched at COP27 in Sharm El Sheikh, compensate countries that agree to protect critical carbon sinks.

NBS are also vulnerable to climate change, however, precisely because they are nature-based. Unless accompanied by deep and rapid emissions cuts and pursued within a general framework of ecosystem restoration and protection, NBS will be under the same threats of ecosystem disturbance, degradation, and species loss as the rest of nature. The level of vulnerability will vary according to type of NBS, local climate, and management approach.

Climate change thus imposes limits to adaptation provided by NBS and exacerbates the risk that carbon stored by NBS is re-released to the atmosphere. This risk can be mitigated through policy measures, for example, requiring buffer accounts with credits set aside for surrender in the event of reversal, clarifying liability in the event of reversals, or aggregating multiple NBS projects.

To minimize confusion, the Commission refrains from using the term NBS elsewhere in this report and instead refer to biological CDR methods, nature-based adaptation measures, or actions that perform both functions.

A variety of methods can store carbon in inorganic forms. Bioenergy with carbon capture and storage (BECCS) is a hybrid method that uses biomass to remove carbon from the air but then stores it as CO_2 underground. Direct air carbon capture and storage (DACCS) is an industrial process that captures CO_2 directly from the atmosphere and stores it underground. DACCS is currently a costly method with few co-benefits. However, its costs should decline over time through innovation and learning-by-doing and if economies of scale can be achieved. DACCS facilities can be sited close to both underground storage and renewable energy resources. Both BECCS and DACCS facilities inject compressed CO_2 underground using methods developed for CCS from industrial processes. In its more optimistic scenarios, the IPCC assumes several hundred billion tonnes of CDR could be stored via these two methods through 2100.[74]

Enhanced weathering adds ground minerals to soils where natural processes weather the material, releasing alkaline minerals that run off to the ocean. Ocean alkalinity enhancement would directly add alkaline minerals to the ocean. Both enhanced weathering and ocean alkalinity enhancement aim to accelerate the natural but slow weathering reactions that remove CO_2 from the air and store it as dissolved carbonates in the ocean. Inorganic CDR methods are relatively immature; implementing them at large scale requires investing in research, development, and demonstration now.

Methods that store carbon by injecting it underground generally offer the highest confidence in the quantity of long-term storage. For methods based on increasing ocean alkalinity, carbon storage is secure but challenging to accurately quantify.[75] Methods that store organic carbon on land are relatively simple to quantify in the short term but less certain in the long term because some fraction of the organic carbon is likely to be released back to the atmosphere as a result of wildfires, droughts, or changes in land management.[76] Inorganic methods are also generally more expensive than methods that store organic carbon in ecosystems as well as many existing emissions reduction options with potential for rapid, large-scale expansion.[77] Lastly, they are less developed than biological methods and require more innovation.

Methods vary in associated benefits or risks. The protection and restoration of degraded ecosystems using biological CDR methods will generally offer carbon storage with the largest ecological co-benefits – such as biodiversity conservation, water regulation, and climate resilience – provided that governance systems require such multiple benefits. (Programs and policies often promote biological CDR methods for these reasons.) Enhanced weathering may improve soils and agricultural productivity, and both enhanced weathering and ocean alkalinity enhancement counter ocean acidification. Finally, BECCS would displace fossil fuels but also require biomass harvesting that is often harmful (involving land competition, fertilizer use, water scarcity, and biodiversity loss), whereas DACCS offers no environmental co-benefits and requires significant amounts of energy.

Finally, CDR methods vary in the relative importance to them of ecosystems and industrial processes. At one extreme, natural ecosystems play central roles in biological CDR methods such as reforestation and wetlands restoration, whereas at the other extreme DACCS is wholly industrial. Most methods require some combination of industrial and ecological processes.

Governance challenges

CDR will be costly. Governments will need to either purchase or implement CDR themselves or incentivize or require other actors to do so. Governments can motivate carbon removal using:

- tax credits (as for example in the US Inflation Reduction Act),
- feed-in tariffs,
- contracts for difference (based on a mutually agreed "strike price"),
- results-based payments (for biological CDR, for example),
- carbon takeback obligations requiring fossil fuel companies to remove and store a steadily increasing proportion of the carbon generated by the products they sell, or
- modifications to emissions trading schemes.

Current policies on CDR are limited. The original text of the UNFCCC endorsed carbon removal by "sinks" and storage in "reservoirs," and the Paris Agreement calls for achieving a balance between emissions reductions and removals by sinks in the second half of this century.[78] The Agreement's Article 6.4 Mechanism may eventually issue credits for CDR activities, although moving in this direction has been contentious.[79] The EU is currently considering a CDR Certification Framework that could allow for the integration of removal credits into the EU Emissions Trading System.[80] The US is supporting CDR through funding for research and development, tax credits, grants, and loans.[81] In the absence of dedicated policy, the development of CDR is substantially influenced by intellectual property regimes, raising concerns about access and equity.

Governments will need to undertake five tasks to promote CDR.

- **First**, they should ensure a reliable system for measuring and verifying removals is in place.
- **Second**, they should provide for robust accounting frameworks.
- **Third**, they should safeguard the permanence of CO_2 storage on an unprecedented centuries-long timeframe by, for example, requiring buffer accounts, clarifying liability, or aggregating projects.
- **Fourth**, governments will need to mitigate other risks (such as those associated with biomass harvesting) while encouraging co-benefits, which can be especially large with some biological CDR methods.
- **Finally**, governments will need to prevent cheap removals from weakening incentives for cuts in emissions, by making clear that emissions cuts and removals are not substitutable; for example, by establishing separate targets for CDR and emissions cuts.

At the global level, the enormous costs entailed in using CDR to achieve net-zero emissions, especially methods that store carbon in inorganic form, raise serious concerns about how to ensure an equitable distribution of burdens. Cost-sharing could be guided by the principle that those who cause harm have a duty to remedy it. This could be operationalized by distributing costs across countries based on past and ongoing emissions, wealth, and/or population, for example, or assigning costs to "carbon majors" based on contributions to cumulative emissions.

Recommendations

The Commission recommends the following initiatives relevant to CDR.

01 **First, governments should promote rapid expansion of higher quality CDR featuring co-benefits and permanent storage, at scale and speed sufficient to materially reduce mid-century climate risks and contribute to keeping any overshoot as small and short as possible.**[82] Governments may reasonably choose different portfolios of higher quality CDR featuring different mixes of methods. The approach to biological CDR should aim at maximizing the co-benefits of these approaches while minimizing the risk that carbon stored is re-released to the atmosphere. Some amount of CDR that stores carbon as inorganic material will be necessary, since reducing climate risks and limiting overshoot will require secure and reliable storage.

02 **Second, large-scale CDR will depend on government action, so governments should undertake, require, or incentivize CDR innovation and expansion.** Government policies and programs – including but not limited to carbon markets – should promote research, development, assessment, and rapid scaling of higher-quality CDR. Government initiatives should aim to drive down costs and should provide for robust accounting frameworks and measurement and verification protocols; methodologies should be stringent to prevent greenwashing.

Policies and programs should be designed to safeguard permanence, promote co-benefits, and manage risks of CDR methods while considering specific environmental and socioeconomic contexts. In view of variability in permanence, co-benefits, and risks, policies should *not* treat carbon removals as substitutable for feasible emissions reductions and should potentially establish a proportion between the two or separate targets reflecting their qualitative difference. This separation is essential to ensure that CDR does not displace emissions cuts.


Image credit: Climeworks

03 **Third, in the short to medium term, international cooperative efforts to finance CDR implementation globally should be pursued.** One approach could be through "internationally transferred mitigation outcomes" (ITMOs) as provided for under Article 6.2 of the Paris Agreement. ITMOs would allow bilateral or multilateral transfers of carbon removals among countries.[83] Other approaches, perhaps linked to ITMOs, could develop and expand mechanisms aimed at mobilizing funding to restore carbon sinks, including through results-based payments for carbon removals.

04 **Fourth, countries should follow the principle that those who cause harm have a duty to remedy it as the global basis for apportioning the costs of large-scale CDR, including for carbon take-back obligations.** The polluters identified as responsible for funding large-scale CDR could be countries, enterprises, or some combination of these.

05 **Fifth, given present uncertainties about CDR methods and consequences, policies to promote rapid expansion of higher-quality CDR should be subject to periodic assessment and updating.** Possible areas for assessment include costs, risks, scalability, timing, and policy performance.

8. Solar Radiation Modification

Key messages

- Solar radiation modification is a controversial proposal for reducing global temperatures by reflecting a small portion of incoming sunlight.
- Such methods could reduce the risks of global warming but could also introduce significant new risks.
- Scientific research is in its early stages and is far from supporting informed decision-making about their use or non-use. More research is needed, including in developing countries, to help determine whether to proceed with this technology and if so how.
- Governance discussions about SRM are in their infancy. Inclusive international dialogues should be initiated as soon as possible.
- The present lack of governance poses its own risks, including the possibility of premature deployment. Therefore, countries should adopt a moratorium on the deployment of solar radiation modification and large-scale outdoor experiments that would carry risk of significant transboundary harm, while expanding research, and pursuing international governance dialogues.

Image credit: ActionVance, Unsplash

Background

The Climate Overshoot Commission's ideal outcome would be that the world rallies around massively accelerated emissions cuts to net zero, enhanced adaptation activities, and scaled-up CDR, all in a manner that supports justice and sustainable development. Growing risks, however, have prompted some scientists to explore a controversial, additional potential set of responses to climate risk, which entail reflecting a small portion of incoming sunlight back into space.

These ideas are variously known as solar radiation modification or management (SRM), solar geoengineering, or climate intervention. They are for the most part theoretical, contain many uncertainties, and are highly controversial.

SRM is drawing increasing attention. Recently, UNEP released a scientific review,[84] the European Commission expressed support for an international scientific assessment and dialogues on governance,[85] and the US identified initial steps toward a research plan and governance.[86] The UN Educational, Scientific and Cultural Organization and the UN Human Rights Council will soon release reports that address it.

The Commission approached SRM with the greatest of caution. It did not deliberate on recommendations concerning its use, but only on recommendations concerning its research and the governance of *possible* future deployment. The Commission is particularly mindful to avoid any suggestion that SRM could offer an alternative to other forms of climate action, and to oppose premature deployment.

At the same time, the Commission found there would also be risks in *not* learning more about the risks and challenges of SRM, or about its potential benefits in a climate-stressed world.

Initial research results, though limited, suggest that SRM might have effects that would reduce the risks from overshoot, should other actions fail to achieve

desired results.[87] However, this is only a minimal threshold assessment, suggesting no more than that the subject should not be ignored. The reason is that SRM use would also introduce significant new risks of its own.

The Commission considered the effects of two forms of SRM: stratospheric aerosol injection (SAI) and marine cloud brightening (MCB). Other approaches have also been proposed. The Commission concentrated on SAI as it is the most researched SRM method.

A lack of scientific understanding and of governance increases the possibility of premature and ill-considered deployment of these technologies, which would fail to take sufficient account of the needs of different countries and communities around the world and the risks that SRM might pose. At the same time, premature rejection of these ideas could also deny countries a potentially powerful tool to reduce risk and lower suffering.

To be clear: the Commission believes that SRM is not an approach that should be relied on or cited in any form as a reason to slow the urgent acceleration of emission cuts. At the same time, the Commission rejects going too far the other way: that SRM should not be discussed at all, that research should be halted, or governance discussions put on ice.

In its consideration, the Commission also recognized that SRM requires meeting the challenge of a truly equitable global deliberation. Developing countries have been inadequately engaged in debates and research on SRM thus far. The Commission believes that they must be fully involved in research activities and political dialogues going forward.

Technical characteristics

SRM refers to a group of proposed technologies that would reflect a small fraction of incoming sunlight back to space – in most scenarios, 1-2 percent[88] – to partially offset climate change. Research has focused on two techniques. (See Figure 8.) SAI would entail increasing the number of tiny particles in the upper atmosphere to scatter sunlight and reduce temperatures. It is inspired by the observed effects of large volcanic eruptions that release sulphates causing global temperatures to decline for about a year. It appears that SAI would be relatively inexpensive, with annual direct costs for a global deployment estimated in the low tens of billions of dollars.[89]

MCB would involve spraying seawater from ships to increase the reflectivity of low-lying clouds. The amount of cooling that MCB could provide is highly uncertain. MCB may turn out to be more suitable as a local adaptation measure, for example, to cool coral reefs.[90] Less researched proposals include cirrus cloud thinning and space-based reflectors.

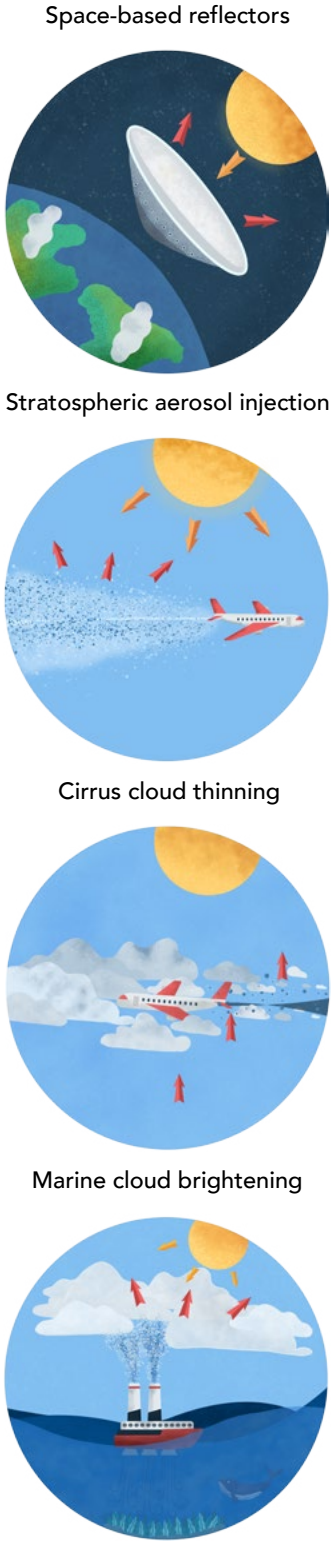
If it were used at large scale, SRM could reduce temperatures within a few years, and would have global effects.[91] To ever be responsible, any such scenario would need to be preceded by a decade-long research program and possibly a multi-decade phased testing period. The climate effects of using SRM would depend strongly on how the changes in reflection are distributed around the world. For a given average cooling, an uneven distribution would cause more climate harm, by shifting aspects of climate such as regional rainfall further away from their preindustrial level, than would an even distribution with the same average cooling[92].

Reflecting sunlight would not address the cause of global warming as it would not affect the levels of greenhouse gases in the atmosphere; it could not substitute for emissions cuts. SRM would not be capable of fully restoring previous climate conditions and could result in unwanted regional climate changes. Poorly planned deployments, for example, using SAI in only one hemisphere, might lower global temperatures overall but could exacerbate climate change in some regions. SRM would also involve environmental impacts such as delayed recovery of the ozone layer, health impacts from particulate matter, and increases in acid rain.[93] SRM would not address the increased ocean acidification caused by the elevated atmospheric CO_2 concentration.

In addition to physical risks, SRM would entail risks related to how it might be used.[94] Implementing, researching, or merely talking about SRM might weaken efforts to cut emissions. Separately, since the effects of SRM would be temporary unless the intervention were continuous or at least repeated, if a large SRM intervention were suddenly halted and not resumed while atmospheric greenhouse gas concentrations remained at unsafe levels, the planet would warm rapidly, producing a potentially very dangerous "termination shock." Finally, the low direct cost of SAI might encourage countries or, at least in principle, private actors to implement the technology unilaterally. Threatened or actual use of SRM could destabilize international politics and raise security concerns.[95] These are the leading reasons why SRM is controversial.

Despite these risks and concerns, the Commission believes it would be imprudent not to investigate or discuss SRM because present evidence suggests the possibility that it could complement other approaches to reducing climate harms in

FIGURE 8 **Solar radiation modification methods.**



ways these others alone cannot, especially in terms of speed – if and when research and testing provides confidence that deployment has acceptable risks.[96] Research to date has been limited, but according to a recent UNEP report, "Modelling studies have consistently shown that climate change (in terms of temperature and hydrological metrics) in nearly all regions is much smaller with a carefully designed SRM deployment than in a world with continued climate change and without an SRM deployment."[97]

Any assessment of the desirability of SRM would need to consider the anticipated costs, risks, uncertainties, and benefits of adding SRM to a world already experiencing climate change.[98] Decisions about SRM will thus inevitably involve difficult and complex risk-risk trade-offs.

Governance challenges

Currently, there is no legally binding governance mechanism dedicated to SRM. Preliminary discussions have taken place, for example, before UNEA in 2019, but have focused only on near-term issues of research and assessment, not concrete governance needs.[99] Yet the existence of governance arrangements for other controversial or novel technologies – such as genetically modified organisms, deep sea exploitation, or even those with stakes as enormous as nuclear, biological and chemical weapons – suggests that governance of SRM is possible, at least in principle.

The prospect of SRM ever being used would present serious governance challenges. Such challenges include reaching international agreement (especially difficult in a fractious geopolitical environment) on whether to use SRM and the scale of any intervention; guarding against the hazard that SRM might

Image credit: Jacek Ulinksi, Unsplash

undermine emissions cuts; establishing effective multilateral or other cooperative mechanisms to prevent unilateral deployment; building reliable management frameworks capable of lasting decades or even centuries under unpredictable geopolitical conditions, to protect against the risk of termination shock; compensating countries demonstrably harmed by SRM; and ensuring meaningful participation in decision-making by communities likely to be affected. Resolving such issues would be very challenging.

The types of governance arrangements noted above, while suggesting that governance is possible, are not perfect analogues for addressing the specific and unprecedented combination of governance challenges that SRM would pose. As such, none of them offers comprehensive guidance for governing SRM in the future. The novelty of SRM and its associated governance challenges, and its potential role in reducing impacts resulting from overshoot, underscore the urgent need to begin international consultations and systematic research on its potential use or non-use of SRM and possible means of governing it. The fact that the impacts of SRM deployment cannot be confined to just one country or region (any intervention large enough to affect the climate in one country or region would also affect climates elsewhere) makes global governance and rules all the more necessary.

The prospect of expanded SRM research also presents governance challenges, less dire but more immediate. SRM research currently under consideration by the scientific community would pose minimal physical risks[100] but may involve socio-political risks like undermining emissions cuts or lock-in. Striking the appropriate regulatory balance between investigation and precaution will be challenging. Additional risk assessment, transparency, and public engagement mechanisms may be necessary.

Recommendations

The Commission recommends the following initiatives pertaining to strengthened SRM governance, strengthened SRM research, and the interactions between them.

01 **First, countries should adopt a moratorium on the deployment of SRM and large-scale outdoor experiments. The moratorium should apply to any intervention with risk of significant transboundary harm, regardless of where it occurs, who carries it out or is responsible for it, what form it takes, or for what purpose.**[101] Interventions below that threshold should comply with countries' environmental regulatory regimes. (See the second recommendation below.) In view of the time and uncertainty involved in negotiating a formal, legally binding treaty, the moratorium should rapidly be adopted by individual states, particularly those that might plausibly be capable of conducting such SRM activities unilaterally.

Governments adopting the moratorium should also call for its adoption by others, coordinating their adoptions through applicable multilateral institutions such as UNEA. The moratorium should remain in effect until advances in scientific research have created a knowledge base strong enough to support informed decision-making on SRM and until an adequate governance framework exists, if these conditions do come about. Periodic reviews would help in assessing progress toward these goals.

02 **Second, governance of SRM research should be expanded.** With respect to outdoor experiments, the appropriate governance depends on their scale[102]. Governance of scientific activities should seek to strike a balance between the need to learn more about SRM and the need for precautionary management of physical risks. Following the principle of subsidiarity, most research currently envisioned can be adequately regulated at the national level using existing regulatory frameworks. Various areas of climate and environmental science regularly conduct field experiments that introduce small amounts of material into the air or water, which are governed by existing regulations and protocols[103]. These mechanisms may be adequate to govern SRM experiments similar to or smaller than these, without additional SRM-specific governance.

Any outdoor SRM experiments should take place only in jurisdictions with an effective environmental regulatory regime. Experiments of larger scale, even below the "significant transboundary harm" threshold of the recommended moratorium, will require additional governance mechanisms, in part to address concerns about potential indirect sociopolitical effects of expanded SRM research. The lower threshold at which additional governance specific to SRM is required could be linked to the scale of impact that triggers the jurisdiction's legal requirement to conduct environmental impact assessments. When triggered by the need for such an assessment, additional governance might include mechanisms to enhance transparency (such as public research registries) and to ensure public deliberation and consultation with potentially affected groups. If it appears that experiments pose particular or novel environmental risks, then a group of independent scientific experts should write guidelines and best practices for the activities. As outdoor experiments expand

in scale, international coordination and harmonization may be warranted. Only legitimate, non-commercial researchers should be permitted to conduct outdoor experiments.[104]

The data, methods, and findings of SRM research should be transparent, including to international audiences. They should be accessible through mechanisms including disclosure of funding sources and open access to publications and data – including, where appropriate, raw experimental data and programming code. Formal research plans should be peer-reviewed and publicly accessible, and results should be independently reviewed.

SRM research should not be led by for-profit firms and should not be funded by sources with an interest in maintaining greenhouse gas emissions, such as fossil fuel interests. SRM research programs should include clear mileposts and exit ramps to reduce the likelihood of "slippery slopes" in which vested interests push for implementation. International research coordination as described above should support and clarify these principles of research governance.

03 **Third, in parallel with strengthening SRM governance, SRM research should also be strengthened; and the two should co-evolve.** Given the risks posed by overshoot and early evidence that some forms of SRM might substantially reduce them, more research on SRM should be conducted.

Critical needs include a better understanding of the effects of SRM on the climate system, greater knowledge of the environmental and societal impacts of SRM, and deeper insight into public views regarding the technology. SRM governance, including possible future global frameworks, should also be researched.

Expanded research, for instance through joint North-South research projects and research led by scientists in the South, should boost the participation and build the capacity of researchers from developing countries. Expanded research should encompass natural science, social science, and interdisciplinary work. Additional research on SRM would represent a tiny fraction of research on climate change: current SRM research funding worldwide is only in the tens of millions of dollars annually while global climate change research funding is in the billions of dollars.[105]

Crucially, given the broad impacts and need for SRM research to be perceived as unbiased and trustworthy, research funding should be transparent. Expanding research does not imply any decision on future use. Results may indicate specific approaches or conditions under which policymakers may judge it advisable to use or may show limitations or risks that suggest it should not be deployed.

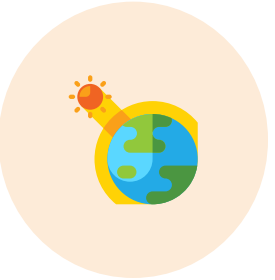
In addition, international coordination of SRM research based on shared priorities shaped by policymakers with equitable North-South representation should be significantly strengthened. Appropriate venues for setting SRM research priorities might include WMO and/or UNEP. Research coordination (including through aligned funding mechanisms) in pursuit of shared priorities might be carried out by the Global Research Council or the Future

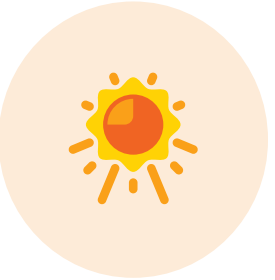
Earth program. International collaboration, involving researchers from different countries working jointly on shared projects, should also be pursued.

04 **Fourth, an international, independent scientific review and assessment of the best available evidence from SRM research should take place every few years.** Assessments should incorporate new research and respond to any gaps or limitations in knowledge identified in earlier assessments. Potential assessment bodies include the IPCC, WMO, and UNEP. (The last of these may be particularly appropriate due to its broader environmental remit.) An assessment of SRM should evaluate the potentials, limitations, and risks of the technology, in the context of the risks posed by elevated atmospheric greenhouse gas concentrations.

05 **Fifth, because the potential use of SRM raises multiple concerns, including novel and severe governance challenges, broad consultations and dialogues on these issues are needed.** The gravity of SRM-related concerns and their high stakes and global impact require that consultations involve a broad range of participants and forums worldwide, including governments, international organizations and a wide range of civil society organizations and other interested parties. Intergovernmental dialogues could take place in various settings, such as the UN General Assembly or UNEA, as well as informal and multi-party settings.

In view of the deep uncertainties about SRM and its governance, these consultations should not initially pursue formal legal or policy action but should instead aim to build shared knowledge and capacity, explore issues and potential responses, and build norms and trust. When issues have ripened enough that intergovernmental decisions about SRM governance are judged appropriate or necessary, these should be based on robust science and assessment, and broadly shared views about acceptable risk trade-offs, precaution, and just and legitimate global decision-making.





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103 Comparable experiments include Free-Air Carbon Dioxide Enrichment; Dispersion of Air Pollution and its Penetration into the Local Environment.

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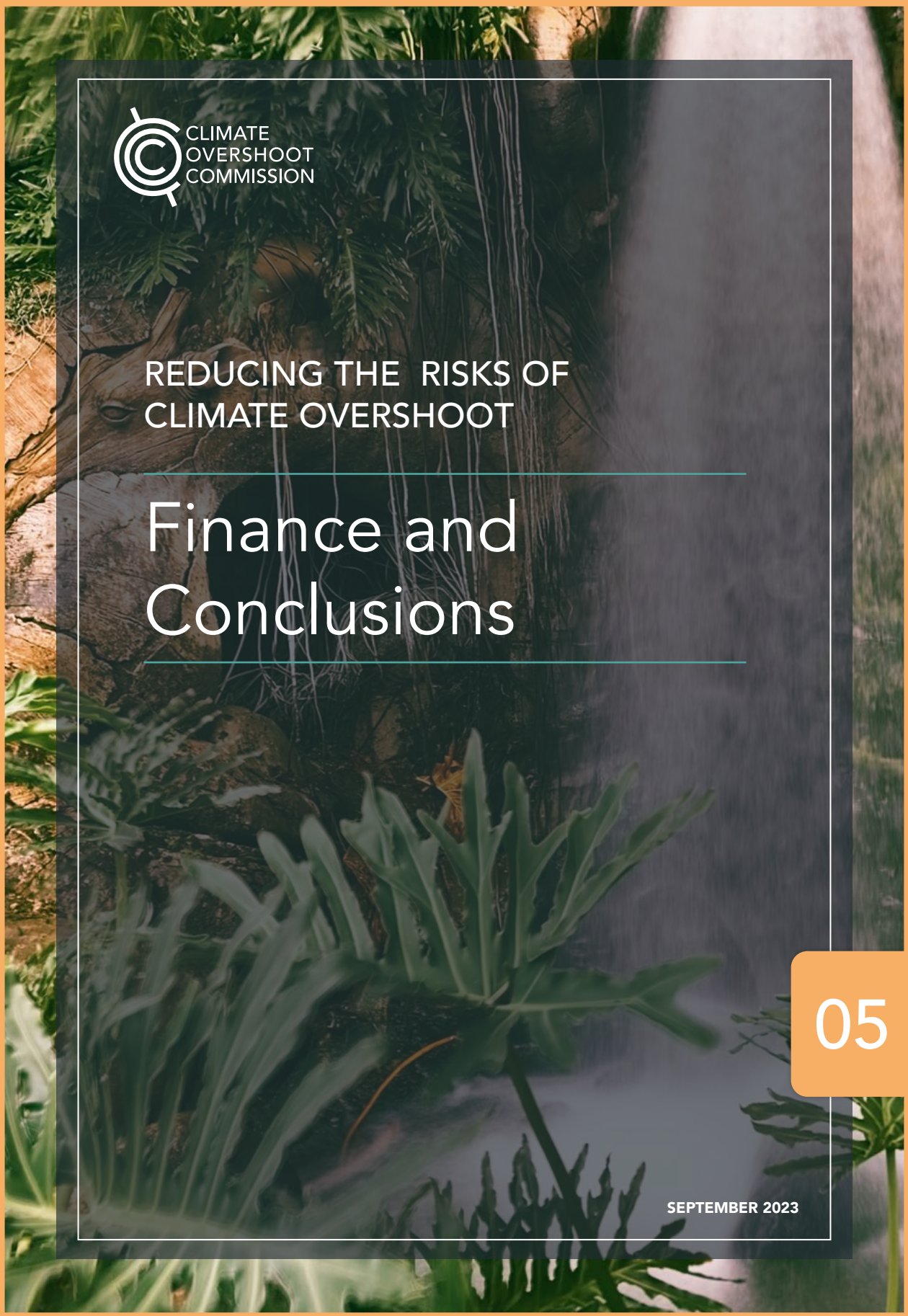


CLIMATE OVERSHOOT COMMISSION

REDUCING THE RISKS OF CLIMATE OVERSHOOT

Finance and Conclusions

05

SEPTEMBER 2023

9. Climate Finance

Key messages

- Climate finance must be increased to prevent or limit climate overshoot. Financing needs are greatest for lower-income countries.
- Massive gaps exist between financial needs and pledges, and between pledges and deliveries. These gaps, which create distrust among developing countries, need to be bridged.
- Public bodies, including international financial institutions and governments, need to mobilize more resources. Reformed development banks equipped with more resources, debt relief, and innovative financial instruments and strategies are needed to achieve this.
- Private capital flows should be massively scaled up, especially for emissions reductions, using de-risking strategies, co-financing, and other emerging approaches.
- New sources of finance and transparent, effective, and efficient carbon markets should also be expanded.

Image credit: Micheile Henderson, Unsplash

Background

Delivering the recommendations in this report will not only require bold new policies, but considerable new financial resources.

There is no agreed definition of "climate finance." According to the IPCC, the term "is applied both to the financial resources devoted to addressing climate change globally and to financial flows to developing countries to assist them in addressing climate change." The Climate Overshoot Commission uses the former, broader definition. The challenge is not only to mobilize more climate finance but to make it more effective and inclusive. Climate finance should be aligned with the goals of the Paris Agreement and the SDGs and support the needs and challenges of different countries, especially the most vulnerable.

Climate overshoot would increase climate financing needs, both for accelerated emissions reductions and for adaptation and resilience. It would also require more investment in CDR.

Needs and gaps

What are the financing needs?

Climate finance can come from public or private sources, domestic or international, and can take various forms, such as grants, loans, guarantees, equity or carbon credits. While there is uncertainty about how much climate finance is currently being provided and how much is required, it is beyond question that what is being delivered falls far short of what is needed.

The global volume of climate finance in 2020 was 665 billion USD, 266 billion in the North and 392 billion in the South.[106] Ninety per cent of the total (586 billion USD) went towards reducing emissions, while only 8% supported adaptation.[107]

Industrialized countries are better able to mobilize the funds needed for their emissions cuts and adaptation, and these funds account for a smaller portion of their economies. According to the World Bank, financing needs for climate action average 1.1% of gross domestic product in upper-middle-income countries, increasing to 5.1% in lower-middle-income countries and as much as 8% in low-income countries. The Independent High-Level Expert Group on Climate Finance estimates the financing needs for developing countries (excluding China), covering emissions reductions, adaptation, and loss and damage, at 2 trillion to 2.4 trillion USD per year by 2030.[108]

Flows of climate finance from developed to developing countries reached 100 billion USD per year in 2023.[109] The original target year for this level, pledged at Copenhagen in 2009, was 2020. In general, there has been a significant and recurring gap between promised climate finance and what has been delivered. This has been aggravated by a lack of transparency and consistency in how climate finance is measured, reported and verified, making it difficult to track progress and ensure accountability.

While 100 billion USD per year is a significant achievement, the actual needs of developing countries are at least 20 times higher. This pattern of "too little, too late" has created a strong distrust among developing countries of the pronouncements and promises made by developed countries at international conferences. The international community must urgently close this gap and enhance the quality, effectiveness and accountability of climate finance.

Climate and development finance are inherently intertwined for developing countries. The actions and investments required to achieve development goals, reduce emissions, and adapt to climate change often overlap. Investments needed to transition from a business-as-usual trajectory to a resilient, low-carbon path include both development spending (e.g., enhancing irrigation systems and crop yields) and climate spending (e.g., making irrigation systems more water-efficient and crop varieties more drought-resistant). In such cases, separating climate from development finance would be shortsighted and inefficient. For developed countries, the investments needed to meet climate objectives mainly involve transitioning to greener technologies, but for developing countries, these investments are intimately connected to broader development goals.

Climate and development issues have been exacerbated in recent years. The Covid-19 pandemic and the energy and food security crisis have reversed decades of progress and pushed 120 million people back into extreme poverty. Climate change hits the poor hardest: they are more exposed and vulnerable to its impacts and have fewer resources and opportunities to adapt. Yet there can be no transition to a low-carbon and resilient future, considering the scope of changes required, with a population that faces poverty, food insecurity, lack of education and health care, and inadequate social protection. More financial resources are needed to tackle both climate change and poverty simultaneously; and the most concessional of those resources must target the poor as a priority.

Recommendations

The Climate Overshoot Commission recommends the following steps to begin to close the climate finance gap.

01 First, public bodies – international financial institutions, developed country governments, and developing country governments – should mobilize and deliver more and better resources for developing countries.

International financial institutions, such as the World Bank, the International Monetary Fund and the regional development banks, need to grow their balance sheets and take more risks, increase their lending and grant-making capacity, and coordinate and cooperate more effectively among themselves and with other partners. During the recent Paris Summit for a new financing pact, Group of Seven countries mentioned an increase of 200 USD billion in financing from all MDBs over the next five years. This is a minimum.

Following this, MDBs will need more capital. Every dollar of additional capital generates several dollars in financing.

Special drawing rights (SDRs), a type of international reserve asset created by the International Monetary Fund, can be used to finance development and climate activities. A 2021 allocation of SDRs worth 650 billion USD provided much-needed liquidity and fiscal space to many countries. Several initiatives have been launched to "rechannel" some of these SDRs from developed countries to developing countries, especially in Africa. A goal of rechanneling at least 100 billion USD of SDRs to developing countries through various mechanisms was agreed to at the Paris Summit. But more rechanneling is required. Some of these SDRs could also be used to strengthen the capital base of regional development banks, which could then lend more to their clients.

Resilience requires specific tools and instruments that can provide liquidity quickly, amply, and unconditionally when disaster strikes. To prepare for and cope with disasters, international financial institutions should consider the establishment of standing financial facilities – pre-arranged credit lines or funds – that could provide liquidity swiftly and on a massive scale to meet immediate needs in the event of a severe climate shock or natural disaster.

More specific mechanisms could also be used more widely, such as Climate-Resilient Debt Clauses in debt instruments, which can defer a country's debt repayments in the event of a predefined climate shock. These tools can offer fast and flexible financing without policy conditions or long negotiations. They can also boost market confidence.

Debt relief is a difficult topic, but considering growing debt distress and near-term disaster risks, we have a duty to act. Specific, innovative mechanisms could also be considered, such as "debt-for-nature" swaps which allow countries to reduce their debt in return for environmental commitments. For example, Ecuador recently bought back 1.6 billion USD of its bonds at a discounted price, pledging to spend more than 323 million USD on conservation on the Galápagos Islands in return.[110]

The global trend of lowering official development assistance (ODA) must be stopped and reversed, and ODA should be more focused, prioritizing the poorest and most vulnerable. ODA from developed-country governments remains a vital source of financing for the least developed countries. It can provide grants, loans, guarantees and technical assistance, catalyze private investment and support domestic resource mobilization. But ODA is under pressure. It should be allocated to climate-related activities when they cannot be financed by the private sector – in particular adaptation. One way to increase the leverage and impact of public finance is to use output-based financing mechanisms, which link payments to results and outcomes rather than inputs and activities.

Domestic resources mobilization and reduction of inefficient and harmful expenditure can complement external financing and enhance fiscal space for climate action and development for developing-country governments. Domestic resource mobilization can be achieved by strengthening tax systems, broadening the tax base, and combating tax evasion and illicit financial flows. Reduction of fossil fuel subsidies, which according to the International Energy Agency (IEA) reached an all-time high of 1 trillion USD in 2022,[111] can free up resources for green investments and social protection, while reducing carbon emissions and air pollution. These measures require political will and social dialogue, as well as international cooperation and support.

02 Second, the private sector should massively increase its capital flows in support of climate action, in both developed and developing countries.

Developed countries use various tools to support green private finance, such as carbon pricing (to encourage low-carbon alternatives), climate information (providing data, standards and taxonomies to assess climate risks and opportunities) and innovative financing instruments (like green bonds). But these tools are not consistent or harmonized across regions, which may, for instance, give rise to trade frictions. (See Section 5.) More policy coordination is needed.

Efforts to issue financial standards for sustainability-related disclosures should be supported, such as those led by the International Sustainability Standards Board that are intended to be interoperable with public frameworks. Different approaches to climate information create confusion and inconsistency for investors and issuers of green financial products.

Private flows for developing countries should be hugely increased. Approximately 210 trillion USD in assets are under private management globally; even a tiny fraction of this total would far surpass the 100 billion USD goal.[112] Boosting private climate finance requires addressing several challenges.

To lower the cost of capital, investment projects in developing countries need proper de-risking. They often face higher risks, either real or perceived, such as regulatory, technological, political, or currency risks. Instruments or strategies like guarantees, insurance, or hedging can assist with de-risking.

Co-financing could support major projects in key sectors, as long as they ensure a fair distribution of benefits and risks between public and private investors. Instruments such as equity stakes can overcome the challenge of limited availability and affordability of private finance due to large upfront capital expenditures and long payback periods of these projects. These instruments should be designed to optimize the use of public funds and avoid crowding out or subsidizing existing investments.

Adjusting risk weights or capital charges for green investment exposure would incentivize private capital. Currently, some climate investments are considered to be riskier because they may be associated with new technologies or emerging markets that can be more volatile. Yet these investments could be rated investment-grade by using more sophisticated risk models that take into account resilience to physical and transition risks and the long-term benefits of reducing carbon emissions. The Basel Committee on Banking Supervision should explore this issue further and propose steps to help accelerate the climate transition and create new opportunities for economic growth.

03 Third, new and underdeveloped sources of finance should be explored and strengthened.

New taxes or levies could raise more revenues for climate finance by taxing activities or sectors that contribute to climate change, such as maritime and air transport and oil and gas. Funds raised in this manner could support development and climate action in general and could also spur decarbonization and innovation in specific sectors. Such taxes or levies would face inevitable political and technical hurdles – including country coordination and taxpayer avoidance – but they could also have additional positive effects, such as deterring harmful behaviour, stimulating innovation and creating a level playing field. Such taxes or levies have already been implemented or proposed by some countries or regions. Several countries have called on the International Maritime Organization to explore a levy on international shipping; this should be encouraged.

Market mechanisms that can generate carbon credits for emissions reductions or removals could mobilize significant private finance for climate action, but so far this potential has not been fully met. Carbon credits are tradable instruments that represent a certain amount of carbon emissions reduced, avoided, or removed from the atmosphere. Buyers can purchase credits to voluntarily offset their own emissions or to comply with regulatory obligations. Entities that are awarded credits can sell them in the carbon market to monetize their decarbonation activities.

Image credit: Markus Spiske, Pexels

Carbon credit mechanisms face several challenges, however, such as:

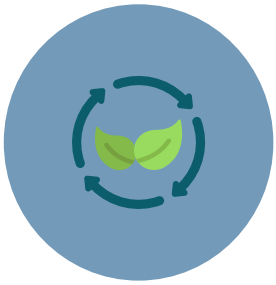
- ensuring that carbon credits represent real, additional and permanent emissions reductions or removals that would not have occurred otherwise;
- avoiding double counting by different entities or jurisdictions;
- ensuring transparency and accountability of credit generation, exchange, and impacts; and
- harmonizing different standards and schemes that certify these credits.

Some reports have exposed serious flaws in some carbon certification schemes, such as over-crediting, leakage, greenwashing and market distortions.

An international public certification mechanism should verify the additionality, permanence and environmental integrity of emissions reduction projects. The UNFCCC Article 6.4 Supervisory Body has begun to take over this task from the Clean Development Mechanism.

While this transition takes place, the World Bank could be entrusted with the responsibility to immediately reinforce the standards currently used in the market, as it has experience and expertise in setting and enforcing standards for green finance and climate action.

The Commission also suggests exploring mechanisms for making carbon credits eligible for small direct payments from public funds, in order to motivate further decarbonization, especially for landowners who successfully preserve forested land or who restore degraded landscapes in developing countries. Such mechanisms could follow the results-based climate finance approach, which links payments to verified outcomes, while carefully ensuring equity, additionality, and sustainability.



10. Synthesis and Integration

Key messages

- Pursuing any single approach to addressing climate change – emissions reduction, adaptation, carbon dioxide removal, or potential use of SRM – can affect other approaches.
- Positive spillovers should be encouraged, and negative spillovers discouraged.
- **C**utting emissions, **A**dapting to impacts, **R**emoving carbon from the atmosphere, and **E**xploring SRM – a CARE agenda – holds the promise of reducing overshoot risks while furthering goals of justice, equity, and sustainability.

Image credit: Renny Gamarra, Unsplash

As the Climate Overshoot Commission completed this report, the world experienced the three hottest days ever recorded. Massive wildfires in Canada turned the skies over New York red, and heatwaves seared societies across the globe. Yet if we continue on this current course, these could be remembered as some of the cooler years of the 21st century.

We are living through a climate crisis right now and are on track for even worse. Climate overshoot is not inevitable, but it is getting closer. Reducing and managing the risks of overshoot is a grave global challenge that will require decades to address successfully, yet the world is still not acting as though it understands what lies in store.

Pursuing – or rejecting – the approaches identified above would have significant consequences not only for climate, but also for development, finance, technology, trade, and human rights. To be effective, global governance must encompass these and other fields and tie them together in ways that break down policy silos and identify cross-cutting effects. Holistic thinking is needed, and new or reformed global institutions may be necessary to put such thinking into practice.

Emissions reductions and carbon removal are the primary tools available to limit the magnitude and duration of overshoot. Adaptation should be aimed at reducing the impacts from any realized level of overshoot. SRM, if ever judged acceptable and prudent, would have the same purpose.

Learning more about all four approaches would be a no-regrets approach grounded in precaution. This may involve considering appropriate roles for different kinds of technologies. Discussions, consultations, and decision-making about all of them should be inclusive and ensure the involvement and participation of developing countries. Governments will be central to these processes, which will necessitate substantial capacity-building efforts.

Image credit: Patrick Perkins , Unsplash

Spillovers

Pursuing one approach can sometimes produce benefits more typically associated with other approaches. Sometimes, however, the effects of one approach can undermine the benefits produced by another. Some of these spillovers – positive and negative – can be foreseen, but some cannot. Furthermore, spillover effects may change as experience of climate change and responses unfolds and as knowledge and capabilities advance.

Some positive spillovers associated with different approaches are already apparent. Cutting emissions can also strengthen resilience. For example, building public transport systems to reduce emissions can help with disaster response.

Similarly, adaptation initiatives can lower emissions. For example, enhancing energy reliability to boost resilience involves increasing energy efficiency, which reduces emissions. CDR projects can benefit adaptation, and adaptation measures can remove and store carbon from the atmosphere. Forestry activities can do both.

Most forms of climate action could have positive spillovers on a broader range of SDGs, encouraging a cleaner, more equitable economy focused upon the well-being of people and ecosystems. There are massive economic opportunities to grab here; the challenge is to make sure those opportunities can be grabbed by everyone.

Negative spillovers can also arise. Emissions reductions are the primary way to tackle overshoot, so it would be particularly worrying if policymakers were tempted to relax or delay efforts to cut emissions in response to implementing or even considering CDR, adaptation, and/or SRM.

Recommendations

The Climate Overshoot Commission recommends the following steps to promote positive spillover effects and discourage negative spillover effects. These recommendations pertain specifically to interactions between different kinds of climate action and are additional to the recommendations made in preceding sections.

01 **First, in constructing a complete portfolio of climate finance projects, special attention should be paid to projects featuring positive spillovers.** These include, for example, emissions reduction projects that also benefit adaptation, and responses with positive spillovers for broader sustainable development and biodiversity goals.

02 **Second, forestry, and in particular efforts to slow and ultimately stop deforestation, should be given higher priority in climate policymaking.** Forestry projects can store carbon and build capacity to cope with climate impacts.

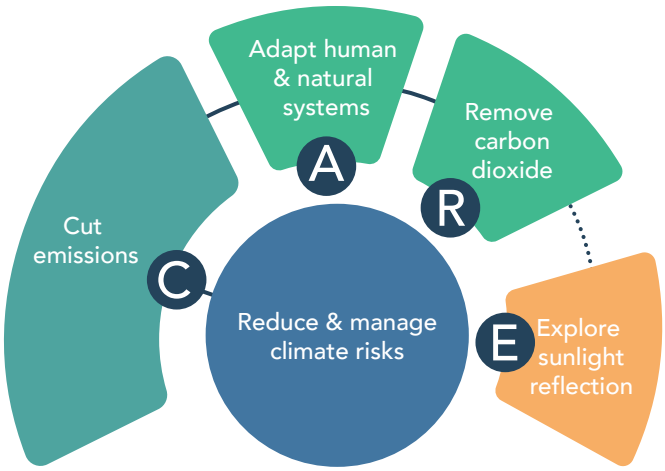
03 **Third, to ensure that CDR does not displace emissions cuts, CDR policies should not treat carbon removals as substitutable for feasible emissions reductions.**

04 **Fourth, in pursuing these different approaches, care must be taken not to exacerbate existing inequities, particularly when it comes to historically marginalized groups.**

A CARE Agenda

Taken together, the recommendations made by the Commission constitute integrated components of a "**CARE Agenda**" for reducing risks from climate overshoot:

FIGURE 9 **Synthesis.**



As this report has stressed throughout, emissions cuts must come first. They will need to be accompanied by more expansive and better financed adaptation measures as well as by a scaling up of carbon removal, including organic and inorganic methods. SRM interventions with risk of significant transboundary harm must be subject to a moratorium, but this technology must also be carefully researched and seriously discussed.

Had countries acted responsibly decades ago, emissions cuts would have been sufficient to address climate change, but adaptation is now essential, while the increasing likelihood of overshoot makes CDR virtually unavoidable. Unfortunately, prudent risk management also demands learning more about SRM in case conditions continue to deteriorate. Caring for people and the planet means doing what we know we must, while equipping ourselves with knowledge that may prove vital in the future.

C

Cut emissions

Accelerate emissions reductions and consolidate decarbonization.

A

Adapt

Expand adaptation and fully mainstream into development.

R

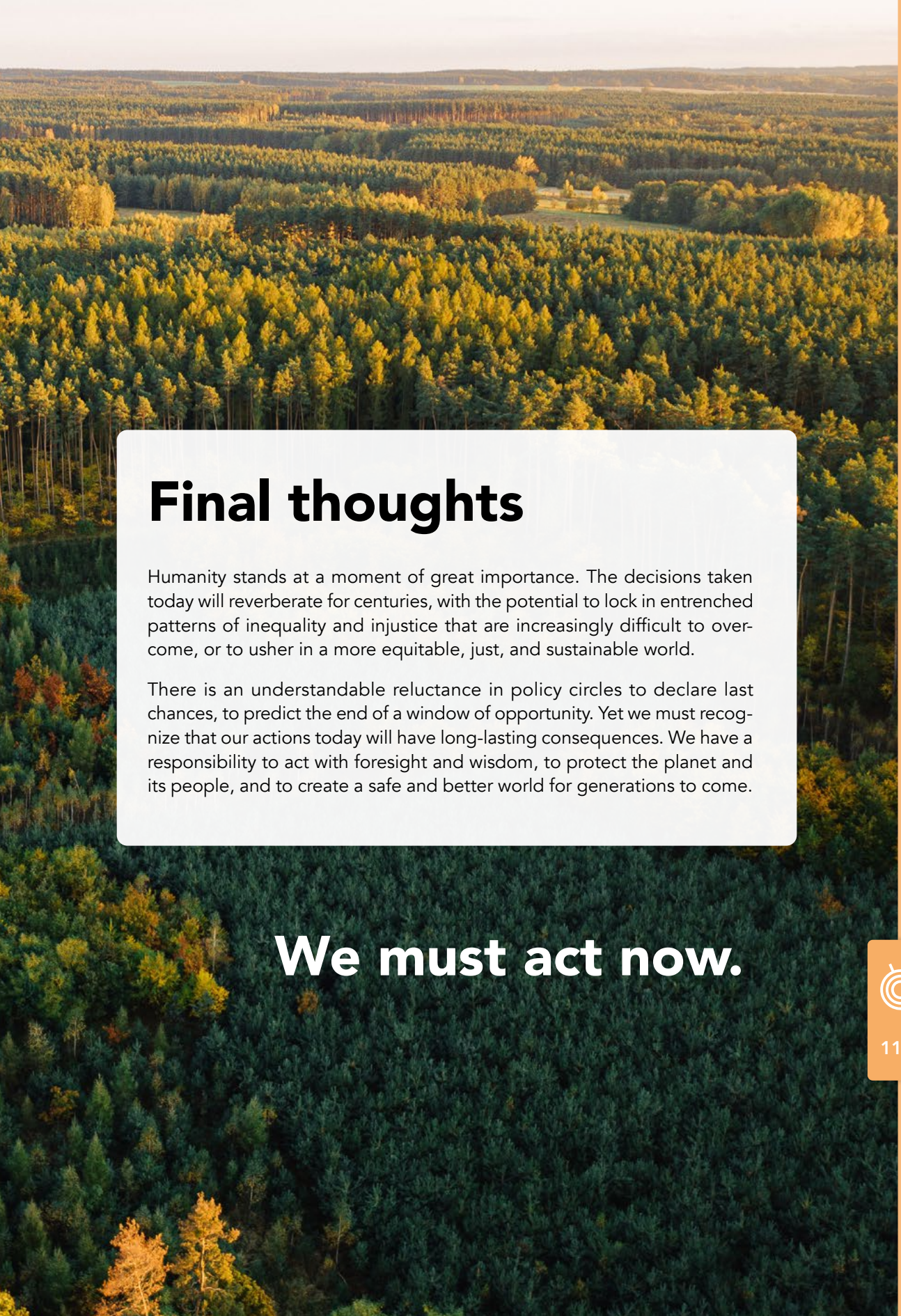
Remove

Develop and deploy higher-quality carbon dioxide removal to help achieve net-zero emissions targets and beyond.

E

Explore

Adopt a moratorium on large-scale solar radiation modification and expand research and governance dialogue.



Final thoughts

Humanity stands at a moment of great importance. The decisions taken today will reverberate for centuries, with the potential to lock in entrenched patterns of inequality and injustice that are increasingly difficult to overcome, or to usher in a more equitable, just, and sustainable world.

There is an understandable reluctance in policy circles to declare last chances, to predict the end of a window of opportunity. Yet we must recognize that our actions today will have long-lasting consequences. We have a responsibility to act with foresight and wisdom, to protect the planet and its people, and to create a safe and better world for generations to come.

We must act now.

Endnotes

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Abbreviations

BECCS	Bioenergy with carbon capture and storage
CCS	Carbon capture and storage
CDR	Carbon dioxide removal
CGIAR	Consortium of International Agricultural Research Centers
CO_2	Carbon dioxide
COP	Conference of the Parties
DACCS	Direct air carbon capture and storage
EU	European Union
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ITMO	Internationally transferred mitigation outcome
JET-P	Just Energy Transition Partnership
MCB	Marine cloud brightening
MDB	Multilateral development banks
NDC	Nationally Determined Contributions
ODA	Official development assistance
SAI	Stratospheric aerosol injection
SDG	Sustainable Development Goals
SDR	Special Drawing Right
SRM	Solar radiation modification
UN	United Nations
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization

Commissioners

Commissioners contributed to the report in their personal capacities. Their views may not reflect those of their affiliated organizations.

Mr. Pascal Lamy, Chair

Vice-President of the Paris Peace Forum; former Director-General of the World Trade Organization, France

Pascal Lamy is the Vice President of the Paris Peace Forum, and the current Chair of the European branch of the Brunswick Group. He coordinates the Jacques Delors Institutes (Paris, Berlin, Brussels). Mr. Lamy is also President or member of various boards with a global, European or French vocation. He is an affiliated professor at the China Europe International Business School CEIBS (Shanghai) and at HEC (Paris). From 2005 to 2013, Mr. Lamy served two consecutive terms as Director-General of the World Trade Organization. He was previously European Trade Commissioner, Director General of Crédit Lyonnais, Chief of Staff of the President of the European Commission, Jacques Delors and his G7 Sherpa, Deputy Chief of Staff of the French Prime Minister and to the French Minister of the Economy and Finance.

Dr. Muhamad Chatib Basri

Former Minister of Finance of Indonesia

Muhamad Chatib Basri is a former Minister of Finance of Indonesia. Previously he was the Chairman of the Indonesian Investment Coordinating Board. Dr. Basri is now the Chairman of the PT Bank Mandiri tbk. and Chairman of the PT XL-Axiata tbk. He is a member of various International advisory councils including the High-Level Advisory Group on Sustainable and Inclusive Recovery and Growth formed by the World Bank and the International Monetary Fund in the face of dual crisis posed by COVID-19 pandemic and climate change; the World Bank Advisory Council on Gender and Development; Group Eminent Personalities of the Organisation for Economic Co-operation and Development Development Centre and the Advisory Board, Centre for Applied Macroeconomic Analysis, the Australian National University. Dr. Basri is also a member of the Governing Board of the Lee Kuan Yew School of Public Policy, National University of Singapore. His expertise is International Trade, Macroeconomics and Political Economy.

Ms. Frances Beinecke

President Emerita, Natural Resources Defense Council; board member, World Resources Institute, United States

Frances Beinecke is President Emerita of the Natural Resources Defense Council (NRDC), a US based environmental nonprofit with 3 million members and activists that works internationally to curb global warming, protect people's health, preserve wild landscapes, and foster vibrant and sustainable communities. Using legal and scientific expertise, NRDC works to design, implement and enforce the laws and policies that protect our environment. In 2010, She was appointed by President Obama to the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. Ms. Beinecke sits on the boards of World Resources Institute, the NRDC Action Fund, and ClientEarth. She is a member of the Council on Foreign Relations. She is a graduate of Yale College and the Yale School of the Environment.

The Right Honourable Kim Campbell

Canada's 19th Prime Minister, Founding Member of the Club de Madrid

After holding elected office at all three levels of Canadian government, Kim Campbell served as Canada's nineteenth and first female Prime Minister in 1993. She was also the first woman to hold the Justice and Defence portfolios. Ms. Campbell is a founding member of the Club de Madrid and of the Council of Women World Leaders (Chair Emerita). She was global President of the International Women's Forum. Trained as a Political Scientist (Soviet Specialist) and a lawyer, in 2014 Ms. Campbell created the groundbreaking Peter Lougheed Leadership College at the University of Alberta, serving as its Founding Principal until 2018. In 2021, she joined the board of the Glen Gould Foundation and the advisory board of The Vancouver Anti-Corruption Institute, a project of The International Centre for Criminal Law Reform and Criminal Justice Policy (ICCLR). Ms. Campbell resides in Florence, Italy with her husband, Hershey Felder.

Mr. Jamshyd Godrej

Chairman of the board of Godrej & Boyce Mfg. Co. Ltd. and of the Council on Energy, Environment and Water, India

Mr. Jamshyd N. Godrej is the Chairman of the Board of Godrej & Boyce Manufacturing Company Limited. He graduated in Mechanical Engineering from Illinois Institute of Technology. Mr. Godrej is the Chairperson of the Board of Directors of the Council on Energy, Environment and Water; Shakti Sustainable Energy Foundation; India Resources Trust; and CII Sohrabji Godrej Green Business Centre. He is a Director of World Resources Institute, USA. Moreover, Mr. Godrej is a Trustee of the World Wide Fund for Nature in India, and also a Trustee of the Asia Society in the USA. He is a member of the Board of Governors of the Centre for Asian Philanthropy and Society, and the Past President of Confederation of Indian Industry and also of the Indian Machine Tool Manufacturers' Association. The President of India conferred on Mr. Godrej the "Padma Bhushan" on 3rd April 2003.

Ms. Arancha González Laya

Dean, Paris School of International Affairs at Sciences Po, former Foreign Minister of Spain

Arancha González is the Dean of PSIA at Sciences Po and first woman to lead the world's third school for Politics and International Studies. Prior to joining PSIA, Ms. González served as Spain's Minister of Foreign Affairs, European Union and Cooperation (2020-2021). She previously was Assistant-Secretary-General of the United Nations and Executive Director of the International Trade Centre (2013-2020). Between 2005 and 2013 Ms. González served as Chief of Staff to the Director-General of the World Trade Organization. Before that she held senior positions at the European Commission in the areas of international trade and development. Ms. González started her career as a lawyer in the private sector.

His Excellency Mahamadou Issoufou

Former President of Niger Republic, President of Issoufou Mahamadou Foundation

His Excellency Mr. Issoufou Mahamadou began his professional career in the mining sector, just after his university studies. His commitment towards values of freedom, justice, democracy, and the rule of law led him to secretly found a political action group from which emerged the Nigerian Party for Democracy and Socialism. In 2011, His Excellency Issoufou was elected President of the Republic of Niger for a term of 5 years and renewed in 2016. He was appointed co-chair of the Presidential Working Group on the Single Currency Project of the Economic Community of West African States, Chairman of the Climate Commission for the Sahel region during the 2015 UN climate summit in Paris, and Chairman of the High-Level Committee for Food Security of the West African Economic and Monetary Union. His Excellency Issoufou's new mission is to help promote peace, democracy, Pan-Africanism, and the climate. To achieve this, he launched the Foundation Issoufou Mahamadou.

Dr. Agnes Kalibata

UN Secretary-General's Special Envoy to the Food Systems Summit; President of the Alliance for a Green Revolution in Africa, Rwanda

Dr. Agnes Kalibata is the President of the Alliance for a Green Revolution. She leads the organization's efforts to ensure a food secure and prosperous Africa through rapid, inclusive, sustainable agricultural growth, improving the productivity and livelihoods of millions of smallholder farmers in Africa. Dr. Kalibata was Rwanda's Minister of Agriculture and Animal Resources, where she drove programs that moved her country to food security helping to lift more than a million Rwandans out of poverty. She served as the Special Envoy of the UN Secretary-General for the 2021 Food Systems Summit. Dr. Kalibata was awarded the Yara Prize, now the Africa Food Prize, in 2012, an Honorary Doctorate from the University of Liège, and the National Academy of Sciences' Public Welfare Medal for her work to drive Africa's agricultural transformation through modern sciences and effective policy thereby improving livelihoods of smallholder farmers. Dr. Kalibata holds a doctorate in Entomology from the University of Massachusetts Amherst.

Ms. Hina Rabbani Khar
Former Minister of Foreign Affairs of Pakistan

Hina Rabbani Khar started public service in 2002, directly elected from Muzaffargarh. Since then, she has been twice elected to Parliament, both from Pakistan People Party's platform. Ms. Khar has served as Foreign Minister of Pakistan, Minister of State for Finance, Minister of State for Economic Affairs and while a member of the Climate Overshoot Commission–Minister of State for Foreign Affairs. Her term as Foreign Minister is best remembered for the 'Regional Pivot' to Pakistan's foreign policy, where Ms. Khar concentrated on building ties with Pakistan's immediate neighbours. This included the normalization of trade relations with India and a policy of reaching out to all political parties and ethnicities in Afghanistan. Her tenure in Finance & Economic Affairs led Pakistan's bilateral and multilateral economic diplomacy. Ms. Khar graduated from the prestigious Lahore University of Management and Sciences with a BSC in Economics and later received her Master's in Management from the University of Massachusetts Amherst.

His Excellency Anote Tong
Former President of the Republic of Kiribati

Anote Tong is a former President of the Republic of Kiribati, serving three terms from 2003 to 2016. During his terms in office, he was responsible for drawing international attention to the existential threat faced by people in countries affected by climate change. Pres. Tong continues to speak at conferences and institutions worldwide. He was responsible for declaring what was then the largest marine protected area, which was later listed by UNESCO as a World Heritage Site. For his advocacy work on climate change and ocean conservation, Pres. Tong has been nominated twice for the Nobel Peace Prize, and was awarded with various outstanding prices. He received his B.Sc. from the University of Canterbury, his Master's in Economics from the London School of Economics, as well as an Honorary Doctorate in Engineering from The National Pukyong University, and an Honorary Doctorate in Law from the University of the South Pacific in Fiji.

Prof. Laurence Tubiana

CEO of the European Climate Foundation; former Climate Change Ambassador and Special Representative for COP21 of France

Laurence Tubiana is CEO of the European Climate Foundation (ECF) and a Professor at Sciences Po, Paris. She previously chaired the Board of Governors at the French Development Agency, as well as the Board at Expertise France. Before joining the ECF, Prof. Tubiana was France's Climate Change Ambassador and Special Representative for the 21st UN climate change summit (COP), and as such a key architect of the landmark Paris Agreement. Following COP21 and through COP22, she was appointed UN High-Level Champion for climate action. From 1997-2002, Prof. Tubiana served as Senior Adviser on the Environment to the French Prime Minister Lionel Jospin. From 2009-2010, she created and led the newly established Directorate for Global Public Goods at the French Ministry of Foreign Affairs. She founded in 2002 and directed until 2014 the Institute of Sustainable Development and International Relations (IDDRI). Prof. Tubiana has held academic positions and has been a member of numerous boards and scientific committees.

Prof. Xue Lan

Cheung Kong Distinguished Chair Professor and Dean of Schwarzman College, Tsinghua University, China

Xue Lan is a Cheung Kong Distinguished Chair Professor and Dean of Schwarzman College, Tsinghua University, where he also serves as Director of the Institute for AI International Governance and of the Global Institute for Sustainable Development Goals. Prof. Xue's interests include science, technology and innovation policy; crisis management; and global governance. In China, he is a Counsellor of the State Council, Chair of the National Expert Committee on the Governance of Next Generation of AI, and a member of the Standing Committee of Chinese Association of Science and Technology. Internationally, Prof. Xue serves on the UN Committee of the Experts on Public Administration, the Sustainable Development Solution Network's board, and Internet Governance Forum Leadership Panel. He is an adjunct professor at Carnegie Mellon University and a non-resident senior fellow of the Brookings Institution. Prof. Xue has received the National Medal of Innovation Excellence, the Distinguished Contribution Award from the Chinese Association of Science and Technology Policy, and the Fudan Distinguished Contribution Award for Management Science. Prof. Xue holds a PhD in Engineering and Public Policy from Carnegie Mellon University.

Science advisors

Science advisors contributed in their personal capacities. The report may not reflect their own views.

Prof. Chris Field

Director of the Stanford Woods Institute for the Environment and Professor for Interdisciplinary Environmental Studies

Prof. Field's research focuses on climate change, especially solutions that improve lives now, decrease the amount of future warming, and support vibrant economies. Recent projects emphasize decreasing risks from coastal flooding and wildfires. He has been deeply involved with national and international efforts to advance understanding of global ecology and climate change. Prof. Field was co-chair of Working Group II of the IPCC (2008-2015), where he led the effort on *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (2012), and *Climate Change 2014: Impacts, Adaptation, and Vulnerability* (2014). His widely cited work has earned many recognitions, including election to the US National Academy of Science's and the American Academy of Arts and Sciences, the Max Planck Research Award, and the Roger Revelle Medal. Prof. Field is a member of the Board of Directors of World Wildlife Fund (US) and the Board of Trustees of the California Academy of Sciences. He is a fellow of the American Association for the Advancement of Science, the American Geophysical Union, and the Ecological Society of America.

Dr. Thelma Krug

Vice-chair, Intergovernmental Panel on Climate Change (through July 2023)

Thelma Krug is a former researcher at the Earth Observation Coordination at the National Institute for Space Research in Brazil, under the Ministry of Science, Technology, Innovation and Communication (MCTIC). She was elected as vice-chair of the IPCC for the Panel's Sixth Cycle (October 2015 – October 2023), after having been co-chair of the IPCC Task Force on National Greenhouse Gas Inventories from 2002 until 2015. Dr. Krug has been Deputy National Secretary at the Secretary on Policies and Programs of Science and Technology at MCTIC; National Secretary at the Secretary on Climate Change and Environmental Quality from the Ministry of the Environment (MMA), and Director of the Department on Policies to Combat Deforestation under the Secretary of Climate Change and Forests at MMA. For more than 15 years, she represented Brazil in the negotiations at the UN Framework Convention on Climate Change, with particular focus on issues related to land use, land-use change and forestry; research and systematic observations; and reporting guidelines.

Prof. Michael Obersteiner

Professor and Director of the Environmental Change Institute, University of Oxford

Prof. Obersteiner is the Director of the Environmental Change Institute (ECI), University of Oxford. His research experience stretches from biophysical modelling in the areas of ecosystems, forestry and agriculture to economics, finance and integrated assessment, and he works across ECI's research themes. Prof. Obersteiner joined the institute from the International Institute for Applied Systems Analysis (IIASA), where he was the Director of the Ecosystems Services and Management (ESM) Program. Prof. Obersteiner joined the IIASA Forestry Program in 1993 and has been leading and developing the ESM Program, which is currently the largest research program at IIASA, since 2011. Under his leadership several national and international organizations, including inter alia the European Commission, WWF, the Organisation for Economic Co-operation and Development, and other national and international institutions have received science-based policy advice using quantitative modelling techniques. Prof. Obersteiner is author of over 250 scientific papers and is a highly cited researcher, ranking in the top 1% of citations in the Web of Science according to Clarivate research.

Youth Engagement Group

Members of the Youth Engagement group provided input into the report. The report may not reflect their own views.

Shirmai Chung

Hong Kong, sustainable finance

Shirmai Chung is a sustainability advocate born and raised in Hong Kong. She is pursuing an MPP at the Hertie School as a Sustainability and Energy Policy Scholar. Before moving to Berlin, Shirmai studied Environmental Studies and Government at Wesleyan University. There, she co-founded the university's Community Fridge Initiative, helped divest a portion of its endowment away from fossil fuels, and taught a student forum on sustainable behaviour and systemic change. Shirmai is interested in contributing non-western perspectives on climate governance.

Alex Clark

United Kingdom, climate economics & China

Alex Clark recently completed his PhD at the University of Oxford, where his research focused on fossil-fuel related economic risks, and how governments and their agents should respond to these risks, with a focus on China. Alex has supported Oxford's engagement with stakeholders in China through the Economics of Energy Innovation and Systems Transition project. He is a former visiting fellow at Harvard Kennedy School and Columbia Climate School, a former Global China Initiative Fellow at Boston University, a former Climate Fellow at the European Council on Foreign Relations. Prior to his doctoral studies, Alex was a climate finance analyst at the Climate Policy Initiative. He holds an MSc from Oxford University and a BA (Hons) from Warwick University.

Louise Mabulo

Philippines, farming and food systems

Louise Mabulo is a chef, farmer, and entrepreneur. She is the Founder of The Cacao Project, which cultivates resilient and Climate-smart livelihoods, positioning farmers for sustainable success in San Fernando, Camarines Sur, Philippines. Louise is a National Geographic Young Explorer, Young Champion of the Earth under the United Nations, a Forbes Asia's 30 Under 30 honouree, Young Activist Summit Laureate and an honouree of Tatler's "Generation T."

Chandelle O'Neil

Trinidad & Tobago, human rights

Chandelle O'Neil is a Sustainable Energy Engineer and Human Rights Advocate in Trinidad and Tobago. They graduated with distinction with a bachelor's degree in mechanical engineering from the University of Guelph Honours program in 2017. Chandelle completed their post-graduate diploma in Global Leadership from the UN Mandated University for Peace, focused on Regenerative Leadership in 2022. Chandelle is a Climate Reality Leader and Youth Climate Expert, focusing on the intersection of gender and climate change. They are currently the National Director for TT with the International Student Environmental Coalition. Chandelle is also a social entrepreneur with their own enterprise, Mawu Energy Services, which supports energy efficiency, sustainable design and resource management established in July 2019.

Yuv Sungkur

Mauritius, small island developing states

Yuv Sungkur is a Mauritian climate advocate. He is passionate about climate change issues and fighting its impact on Small Islands Developing States. He delivered a TEDx Talk in 2022 and spoke alongside UN Secretary-General Antonio Guterres during the United Nations General Assembly in New York in September 2022. He flew to COP 27 in Egypt to represent the interests of Mauritian youth on various climate-related issues (education, climate migration, loss of cultural heritage). Yuv is the founder of a local nongovernmental organization called Food Water Hygiene Mauritius, an organization that aims to support the Mauritian population living in situations of hunger, poverty and inequality by providing food, water and essential hygiene products. He holds an MSc in Global Environmental Governance from Vrije Universiteit Amsterdam, and a BA in Political Science and International from McGill University.

Jeremiah Thoronka

Sierra Leone, energy poverty

Jeremiah Thoronka is an innovator, entrepreneur, and scholar with intimate knowledge of energy, climate change, environment, sustainability, and development. In 2021, he was laureate of the inaugural Global Student Prize and the Commonwealth Youth Awards for Excellence in Development Work - Africa; cited for demonstrating exemplary excellence in innovating Clean Energy Systems, promoting Locally Sustainable Solutions, and Youth involvement in the Sustainable Development Goals. He holds an MSc in Sustainability, Energy, and Development from Durham University as a Commonwealth Shared Scholar.

Secretariat

Jesse Reynolds, Executive Secretary

Adrien Abécassis, Principal and Special Advisor to the Chair

Khalid Tinasti, Director of External Relations

Joshua Horton, Research Director

Sophia Luisa La Marca, Operations Manager

Annelle Lilibeth Gonzalez, Communications Officer

Zarah Kandjee, Administrative Assistant

The Paris Peace Forum

The Commission is hosted by the ***Paris Peace Forum.*** The Paris Peace Forum is a French initiative launched in 2018 to create a multi-actor platform in Paris to address global governance issues. Throughout the year, the Forum works to strengthen the governance of global commons, such as space, cyberspace, or the oceans, and improve the international management of global issues, the development of artificial intelligence and disruptive technologies, or the ecological and social transition of the economy. Its annual event gathers heads of state, government and international organization, as well as civil society and private sector leaders, around concrete initiatives with an emphasis on the global South.

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