Ethen, J Earth Sci Clim Change 2025, 16:1

Journal of Earth Science & Climatic Change

Commentary Open Access

Climate Overshoot: Risks, Realities, and the Road Ahead

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Introduction

The term "climate overshoot" has become increasingly relevant in the discourse on global climate change. It refers to a scenario in which global temperatures temporarily exceed a specific warming threshold—most commonly 1.5°C or 2°C above pre-industrial levels-before eventually being brought back down through mitigation efforts or technological interventions. While the goal of the Paris Agreement is to limit warming well below 2°C and ideally to 1.5°C, current emission trajectories suggest that a temporary overshoot of these targets is likely. This article delves into the concept of climate overshoot, its potential consequences, the tools available to reverse it, and the ethical and policy considerations surrounding this increasingly probable future [1].

Understanding Climate Overshoot Climate overshoot differs from a permanent exceedance in that it implies eventual reversal. However, even temporary overshoots can have irreversible effects. These include the loss of biodiversity, damage to ecosystems, and crossing of tipping points such as the melting of polar ice sheets or the collapse of tropical rainforests.

The Intergovernmental Panel on Climate Change (IPCC) has explored overshoot scenarios extensively in its reports. Many of the pathways that limit warming to 1.5°C include a period of overshoot followed by deployment of carbon dioxide removal (CDR) technologies to return temperatures to target levels. This raises critical questions about the feasibility, ethics, and equity of such strategies [2-6].

Causes and Probability of Overshoot is primarily driven by the delay in global mitigation efforts. Despite the growing deployment of renewable energy and climate policy frameworks, global greenhouse gas emissions continue to rise. The remaining carbon budget to stay within 1.5°C of warming is rapidly shrinking and may be exhausted within the decade if current trends continue.

Key contributing factors to overshoot include:

- Continued reliance on fossil fuels
- Slow adoption of clean energy technologies
- Deforestation and land-use change
- Inadequate climate policy implementation
- Socioeconomic inertia and political resistance

Impacts of Climate Overshoot

1. **Ecosystem Disruption**: Temporary overshoots can cause permanent changes in ecosystems. Coral reefs, for example, are highly sensitive to temperature changes and may not recover even if temperatures decline later. Likewise, Arctic ice loss and permafrost thaw may trigger feedback loops that intensify warming.

2. **Human Health and Livelihoods**: Extreme heat events, crop failures, and water scarcity are likely to intensify during overshoot periods, leading to food insecurity, displacement, and public health crises. Vulnerable populations in the Global South will bear the greatest burden.

3. **Tipping Points and Irreversibility**: Overshooting 1.5°C increases the risk of crossing critical thresholds in the Earth system. These include:

   - o Collapse of the Greenland and West Antarctic ice sheets
   - o Dieback of the Amazon rainforest
   - o Disruption of monsoon systems

4. **Economic Consequences**: The financial costs of overshoot-related damages can be astronomical. Infrastructure destruction, reduced agricultural productivity, and disaster response will strain economies, especially those of developing nations.

5. **Moral and Ethical Concerns**: Overshoot scenarios often assume the deployment of CDR technologies in the future. This places an unfair burden on younger generations and developing countries, who may be tasked with solving a crisis they did not create.

Mitigating Overshoot: Pathways and Technologies

1. **Rapid Emission Reductions**: The most effective way to avoid or minimize overshoot is to accelerate the reduction of greenhouse gas emissions. This requires:

   - o Phasing out fossil fuels
   - o Scaling up renewable energy
   - o Improving energy efficiency
   - o Reducing emissions from agriculture and land use

2. **Carbon Dioxide Removal (CDR)**: Technologies and methods to remove CO2 from the atmosphere include:

   - o Afforestation and reforestation
   - o Soil carbon sequestration
   - o Bioenergy with carbon capture and storage (BECCS)
   - o Direct air capture and storage (DACCS)

While CDR is essential in overshoot scenarios, it is not a silver

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Received: 03-Jan-2025, Manuscript No: jescc-25-165952; **Editor assigned:** 06-Jan-2025, Pre-QC No: jescc-25-165952 (PQ); **Reviewed:** 20-Jan-2025, QC No: jescc-25-165952; **Revised:** 27-Jan-2025, Manuscript No: jescc-25-165952 (R); **Published:** 31-Jan-2025, DOI: 10.4172/2157-7617.1000876

Citation: Ethen S (2025) Climate Overshoot: Risks, Realities, and the Road Ahead. J Earth Sci Clim Change, 16: 876.

bullet. Many methods are unproven at scale, costly, and may have land-use conflicts.

3. **Solar Radiation Management (SRM)**: SRM involves reflecting a portion of sunlight back into space to cool the Earth. Techniques include stratospheric aerosol injection and marine cloud brightening. However, SRM carries significant risks and uncertainties and does not address ocean acidification or other non-temperature-related climate impacts.

4. **Nature-Based Solutions**: Ecosystem restoration, wetland conservation, and sustainable land management can provide low-cost, co-benefit-rich approaches to climate mitigation.

5. **Behavioral and Structural Changes**: Changes in consumption patterns, dietary shifts, urban planning, and circular economy practices can significantly contribute to reducing emissions and slowing the pace of overshoot [7].

Ethical and Governance Challenges Overshoot scenarios raise numerous ethical issues. Who decides which technologies are deployed and where? How are the risks and benefits distributed? What safeguards exist to prevent unintended consequences?

1. **Intergenerational Equity**: Relying on future generations to deploy large-scale CDR technologies is ethically questionable. It shifts the burden of responsibility and introduces long-term risks.

2. **Global Inequity**: Developing countries are least equipped to cope with the impacts of overshoot and may lack access to technological solutions. Equity must be central in climate governance.

3. **Risk of Moral Hazard**: Over-reliance on future technological fixes could reduce the urgency of immediate mitigation efforts. Policymakers might delay action in the hope that future solutions will solve the problem.

4. **Lack of Regulatory Frameworks**: There is currently no international governance structure to oversee the deployment of high-risk technologies like SRM, making their use controversial and potentially dangerous.

Policy Recommendations

1. **Strengthen Climate Ambition**: Countries must enhance their nationally determined contributions (NDCs) and align domestic policies with the 1.5°C goal.

2. **Support Research and Innovation**: Invest in the development and scaling of safe and effective CDR technologies, while monitoring their environmental and social impacts.

3. **Foster Global Cooperation**: International collaboration is essential for fair governance, funding, and knowledge-sharing related to overshoot responses.

4. **Integrate Overshoot into Planning**: Governments and institutions should prepare for potential overshoot scenarios in their climate adaptation and resilience strategies.

5. **Public Engagement and Transparency**: Decisions about future climate interventions must be inclusive, transparent, and accountable. Civil society must have a voice in shaping climate futures [8-10].

Conclusion

Climate overshoot is no longer a hypothetical scenario; it is a looming reality that demands urgent and coordinated action. While it may be possible to return to safer temperature levels through mitigation and carbon removal, the consequences of even a temporary overshoot could be profound and irreversible. The path forward requires ambition, innovation, and above all, a commitment to justice and equity. Avoiding the worst outcomes of overshoot hinges not just on technology, but on our collective willingness to act decisively and ethically in the face of a climate emergency.

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