4. Polar Geoengineering

A new study by the University of Exeter warns that polar geoengineering projects could cause severe environmental damage with global consequences, questioning their viability.

About Polar Geoengineering

Definition - Polar geoengineering refers to deliberate, large-scale human interventions in the Earth's polar regions aimed at slowing global warming, preserving polar ice sheets, or stabilising global climate feedback loops. These methods attempt to modify natural environmental processes—such as solar radiation reflection, ocean circulation, or ice dynamics—to reduce heat absorption and ice melt in the Arctic and Antarctic.

Objective - To prevent catastrophic ice-sheet collapse, mitigate sea-level rise, and maintain polar albedo (reflectivity), which plays a critical role in regulating the Earth's energy balance.

Different Polar Geoengineering Techniques and Their Limitations

Method	Concept & Example	Limitations / Core Issues
1. Stratospheric Aerosol Injection (SAI)	Involves injecting reflective particles such as sulphur dioxide (SO_2), titanium dioxide (TiO_2), or calcium carbonate ($CaCO_3$) into the stratosphere to reflect a portion of incoming solar radiation and cool the planet.	Ineffective during polar winters due to absence of sunlight. Polar regions already have high natural albedo, making additional reflection less impactful. Termination shock risk—sudden warming if the program stops abruptly. Potential for global weather disruption (e.g., monsoon shifts, ozone damage). Lack of liability and governance frameworks for transboundary impacts.
2. Sea Curtains/Walls	Construction of buoyant underwater barriers anchored to the seabed to block warm ocean currents from melting glacier bases (e.g., the proposed barriers near the Thwaites Glacier, Antarctica).	Requires extreme-scale marine engineering in harsh conditions. Very high costs (each specialized ship costs around $0.5 billion). Risk of ecological disruption, altering marine circulation and affecting sea life. Potential release of toxic materials from barrier degradation.
3. Sea-Ice Management (Microbeads)	Proposes scattering glass or silica microbeads on ice or snow to increase reflectivity (albedo) and slow melting.	Massive logistical and operational challenges across vast polar areas. Ecotoxicity concerns—microbeads can harm marine and bird species. May cause net warming by altering atmospheric dynamics. Impractical due to energy-intensive production and supply chains.
4. Basal Water Removal	Involves pumping subglacial meltwater from beneath ice sheets to reduce basal sliding and slow glacier flow into the sea.	Based on a flawed assumption—removal may not sufficiently reduce flow. Requires continuous, energy-intensive pumping operations. High emissions from infrastructure and fuel use. Impractical on a continental ice-sheet scale.
5. Ocean Fertilisation	Adds iron or other nutrients to the ocean to stimulate phytoplankton growth, enhancing carbon dioxide absorption through photosynthesis (tested in Southern Ocean experiments).	Difficult to control biological responses—may lead to dominance of harmful species. Disrupts marine food chains and deoxygenates water. Uncertain long-term carbon sequestration outcomes. • Raises global governance and ethical issues under UNCLOS and CBD.

6. Arctic Ocean Pumps	Deploys wind-powered pumps that spray seawater onto ice during winter to form thicker ice layers.	• Each pump needs ~1 million kWh of electricity per year. • Creates a large carbon footprint, undermining climate goals. • Technologically and logistically unrealistic in remote, freezing conditions. • High maintenance risks and limited area coverage.

Environmental and Governance Challenges

Unintended Consequences - Manipulating polar environments can alter global atmospheric and oceanic circulation, affecting weather patterns far beyond the poles.

Ethical and Legal Dilemmas - Raises questions about who controls the climate and who bears responsibility for unintended damage.

Inequitable Impacts - Could disproportionately benefit or harm regions—e.g., cooling the poles might alter tropical monsoon systems.

Governance Gaps - There is no international regulatory framework specifically governing polar geoengineering; existing conventions like the London Protocol or UNCLOS only partially cover these activities.

Way Forward

Prioritise Climate-Resilient Development - Focus on reducing greenhouse gas emissions through energy efficiency, sustainable infrastructure, and nature-based solutions. Integrate climate adaptation into all development plans, particularly in coastal and polar-vulnerable nations.

Strengthen Protected Areas - Expand marine and terrestrial protected zones in polar regions while incorporating indigenous and local knowledge to preserve biodiversity and ecological balance.

Reduce Fossil Fuel Reliance - Accelerate the global renewable energy transition, modernise electricity grids, and address supply chain bottlenecks for critical minerals essential for clean technologies.

Enhance International Governance - Develop a multilateral framework (possibly under the UN Environment Assembly or IPCC) to assess, monitor, and regulate any proposed geoengineering interventions before deployment.

Conclusion

Lowering carbon emissions remains the most effective, equitable, and scientifically proven pathway to combat climate change. While polar geoengineering may appear as a technological backup, it carries high uncertainty, ethical risks, and potential for unintended harm. Every tonne of CO_2 avoided today enhances climate stability, reduces future shocks, improves air quality, and preserves the integrity of polar ecosystems—benefits that no geoengineering strategy can safely replicate.

Source - [https - //www.thehindu.com/sci-tech/science/polar-geoengineering-projects-could-cause-severe-harm-scientists-say/article70112422.ece](https://www.thehindu.com/sci-tech/science/polar-geoengineering-projects-could-cause-severe-harm-scientists-say/article70112422.ece)