Alternatives to Geoengineering Technology for use in India

The proposed alternatives for existing or upcoming geoengineering technologies in India

Citizen consumer and civic Action Group (CAG)

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Introduction

Geoengineering (or "Earth-engineering") is a deliberate, large-scale intervention in the natural functioning of the planet to slow down or reverse the effects of man-made global warming and climate change. The two main classes of geoengineering are direct carbon dioxide removal and solar radiation management. Both involve release of materials to the environment, either to the atmosphere or to the oceans, in areas beyond national jurisdiction. This affects the intended impact on climate, sometimes to variable extents. Therefore assessing the true impact and outcomes of these techniques can be harder and more complicated. The inherent international implications for deployment of such geoengineering methods (and large-scale experiments) are still under a question mark as their ethical implications and actual ability to tackle climate change continue to be debated.
The special report of the Intergovernmental Panel on Climate Change (IPCC) on the 1.5 degree climate target, published in 2018, had evaluated that global warming can be limited to 1.5 degrees without geoengineering. Most countries have turned down geoengineering as a climate-crisis mitigation tool as the technological manipulation of the earth's climate system carries potential risks to people and ecosystems.

The proposed geoengineering technologies to remove carbon dioxide are going to establish new extractive industries, which will further increase energy and resource consumption as well as transnational supply chains and transport requirements, which are likely to increase emissions rather than reduce it.

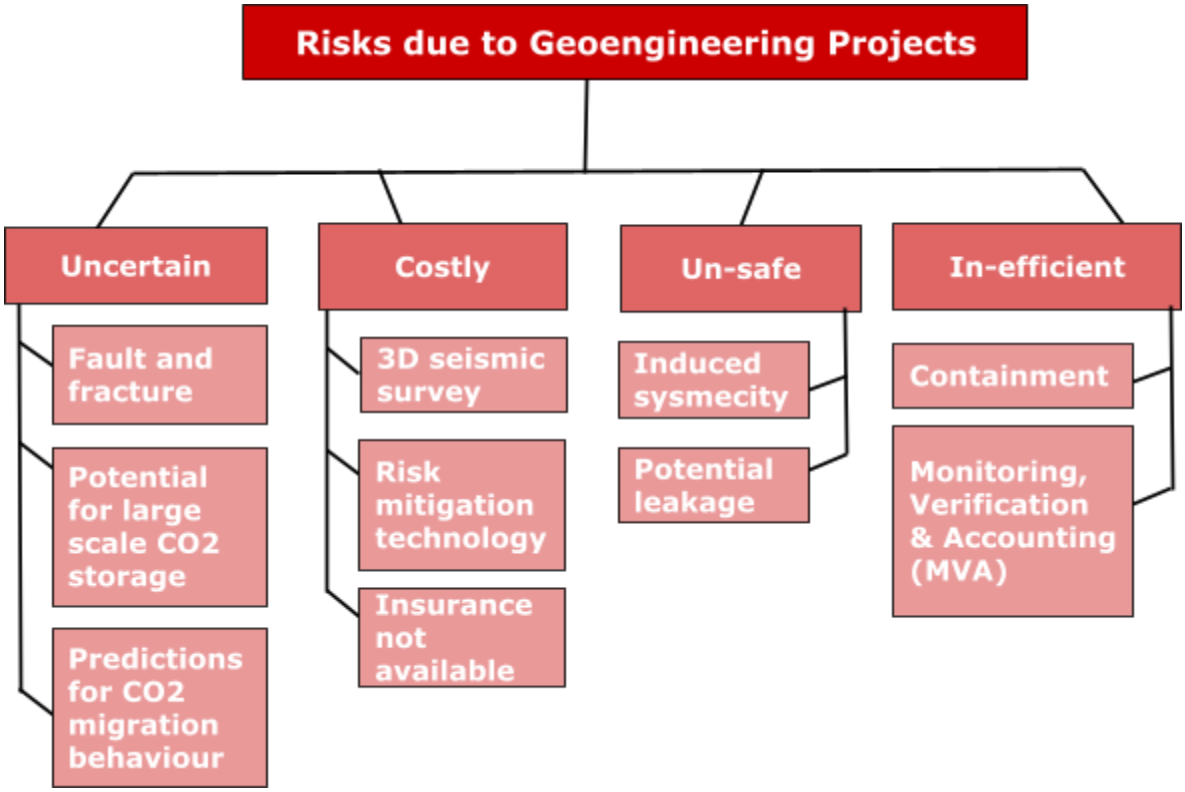

Figure 1: A brief analysis of the risks associated with geoengineering (source: IEAGHG).

Methodology

This review has analysed available research works in the field of geoengineering through the PESTEL (Political, Economic, Social, Technological, Environmental and Legal) framework. Secondary data was sourced from various official websites like Heinrich Böll Foundation, CIEL (Centre for International Environmental Law), CEEW (Council on Energy, Environment and Water), DownToEarth and CarbonBrief. No primary data was collected.

Introduction to Geoengineering Technologies

After World War II, concerns about anthropogenic climate change led to several debates and discussions with proposals to engineer climate through intentional manipulation of the environment to suit human needs.[1] Since then, geoengineering has been promoted as a tool to move the temperature knob of Earth through large-scale interventions carried out in the natural systems to mitigate climate change.

[1] Geoengineering The Climate: History and Prospect

However, studies after the 1970's reflected the significant impact on the balance of nature due to an additional 17 Gt (Gigatons) of anthropogenic greenhouse gases in the atmosphere (see figure 2). This was followed by testing and deployment of geoengineering technologies for long-term climate modifications to tackle CO2-induced climate problems.[2] This resulted in rising concern about the economics, risk and uncertainty, politics and law, and environmental ethics associated with the human management of global carbon and other biogeochemical systems through geoengineering technologies.[3]

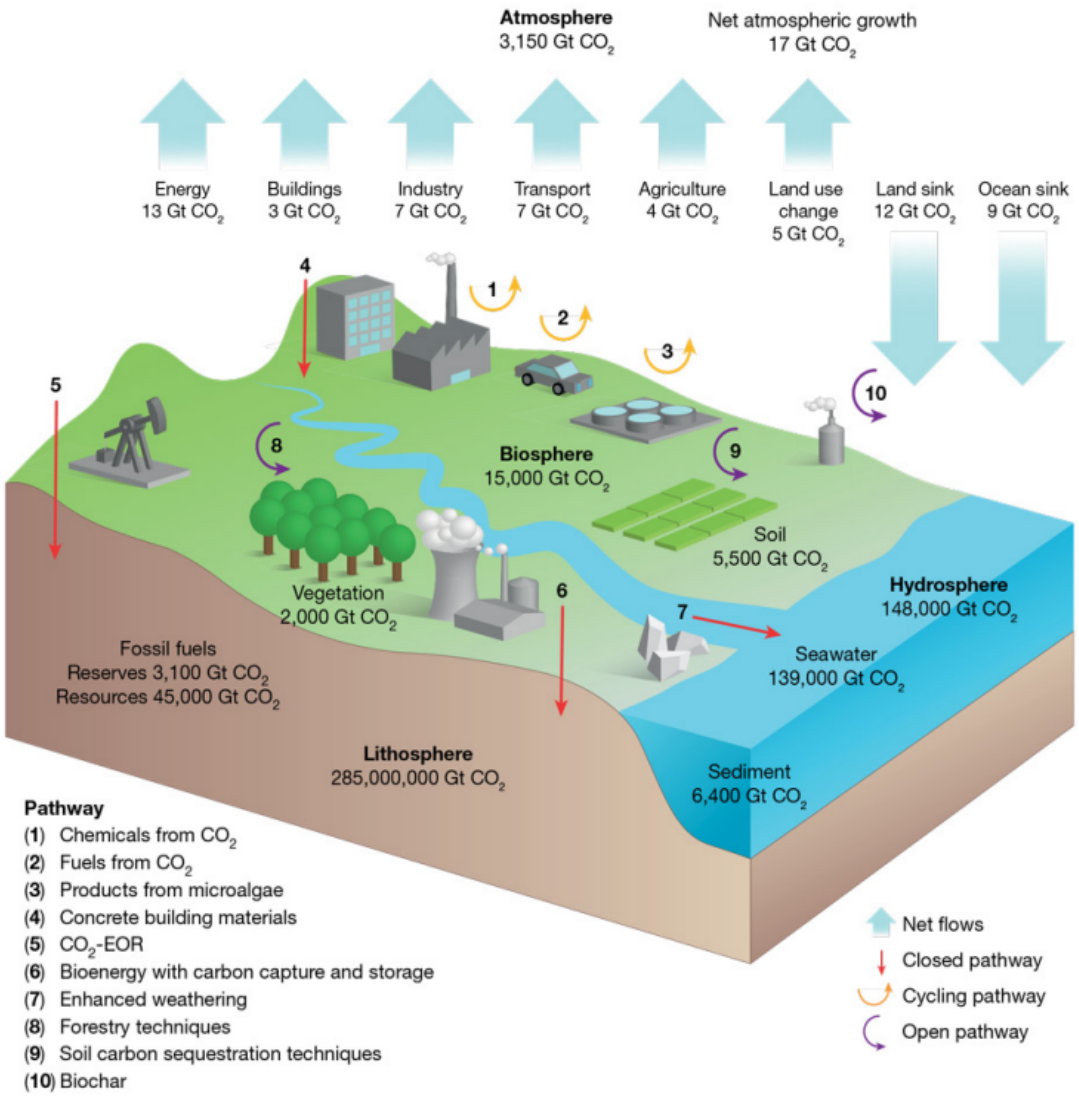

Figure 2: Potential storage and utilisation pathways for CO_2 (source: Hepburn et al., 2019).

[2] Geoengineering: An Idea Whose Time Has Come?

[3] Carbon And Other Biogeochemical Cycles

Table 1: Different types of geoengineering technologies available in the world.

Land based		
1	Carbon Capture and Storage, and Carbon Capture, Use and Storage (CCS / CCUS)[4]	A technology to capture CO2 from power plants and other industrial sources and store it in the sub-surface to significantly reduce carbon emissions. It also encourages CO2 recycling by converting it into value added products, such as urea, methanol and cement, and for Enhanced Oil Recovery (EOR).
2	Bioenergy with Carbon Capture & Storage (BECCS)[5]	Biomass is converted into bio-energy and the emissions from this conversion are captured and stored in geological formations.
3	Direct Air Capture (DAC)[6]	A technology used to remove CO2 directly from the atmosphere with the help of liquid systems like hydroxide solution or solid sorbent filters, which is permanently stored in the sub-surface.
4	Biochar[7]	Biomass is burnt through pyrolysis to produce charcoal and is used as a soil enhancer and to store the burnt carbon.
Ocean based		
1	Marine Cloud Brightening[8]	It is a theoretical solar geoengineering technique that aims to create whiter clouds in order to reflect more sunlight back to space.
2	Ocean Fertilisation[9]	A technology to enhance the ocean solubility of carbon sequestered through natural cycles between surface and deep waters.
3	Microbubbles and Sea Foams[10]	Spreading chemical surfactants through ships to create micro-bubbles. Chemical foaming agents are sprayed on the ocean surface, which floats on latex/polystyrene. Both act as a reflector for sunlight, thus reducing heat trapped by oceans.

[4] Why Should India Think Again About Bringing Carbon Capture Utilisation And Storage (CCUS) Technology In The Country?
[5] Land-Based Geoengineering - A Bad Bet To Stay Within 1.5°C
[6] Direct Air Capture
[7] Biochar (Technology Factsheet)
[8] Marine Cloud Brightening
[9] Ocean Fertilization: A Potential Means Of Geoengineering?

[10] Marine Geoengineering - Not A Quick Fix Escape From Climate Crisis

4	Artificial Upwelling[11]	This technology pumps up the cool and nutrient rich water from the deep ocean to help phyto-planktons to flourish and pull-out CO2 from the atmosphere.
Air based		
1	Solar Radiation Management (SRM)[12]	To reduce the impacts of global heating, various methods such as placing huge reflective mirrors, spraying a fine mist of sea water and chalk and, injecting reflective aerosols like sulfur dioxide (SO2) or titanium dioxide (TiO2) in the upper atmosphere (stratosphere), are proposed to reflect the sunlight back into the space.
2	Cirrus Stripping[13]	Cirrus clouds form at high altitudes and prevent the reflection of sunlight, thus, are thinned out by seeding with aerosol particles or "ice nucleating particles" such as sulfuric and nitric acid, to counteract the greenhouse gas effect.
3	Cloud Seeding[14]	A technology that leads to man-made precipitation by spraying particles of salts like silver iodide and chloride on clouds using a special aircraft, rockets or from dispersion devices located on the ground.

Following are the current geoengineering experiments:

1. **Stratospheric Controlled Perturbation Experiment (SCoPEx):** This is a solar geoengineering project re-launched in 2017 at Harvard University after it was cancelled in 2012.[15] It injects calcium carbonate, sulphur particles or other substances into the stratosphere using aeroplanes or high flying balloons to reflect sunlight back into space to reduce earth's temperature.

[11] Artificial Upwelling (Technology Factsheet)
[12] Solar Radiation Management - A Controversial Approach To Mitigate Global Heating
[13] Climate Change Is Here. It's Time To Talk About Geoengineering
[14] What Is Cloud Seeding?

[15] Current Geoengineering Attempts Briefing: SCOPEX 2021

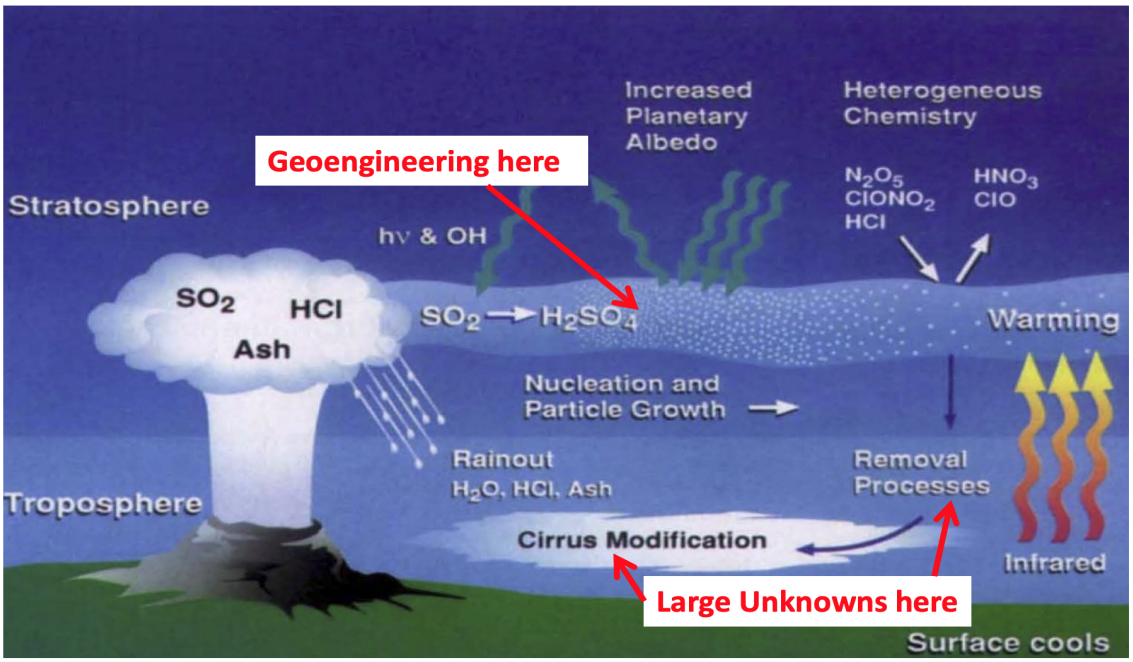

Figure 3: Increasing reflectivity of atmosphere through solar geoengineering (source: cleantechnica).

2. **Ice911:** This is a non-profit organization that proposed a solution to slow down the melting of ice by spreading hollow white silica-glass beads on top of Arctic ice.[16] This method can reduce sea-level rise and other potential disasters due to global warming.

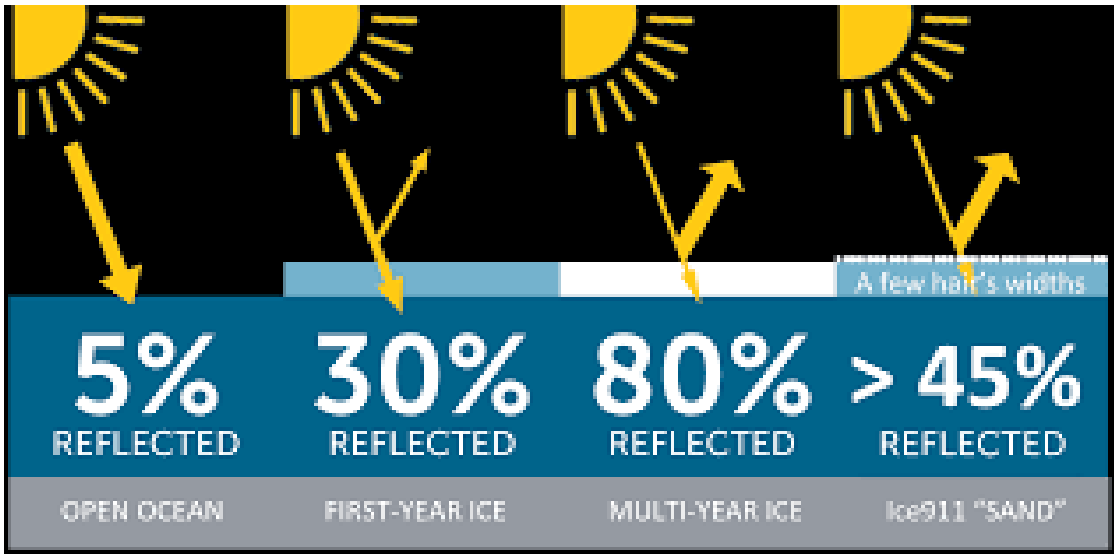

Figure 4: Surface albedo modification for restoration of Arctic ice (source: ESSOAr).

[16] Ice911: How Scattering Tiny Glass Beads Over The Arctic Could Help Restore Ice And Stabilise The Climate

The " Geoclique " is a group of researchers who hold patents on individual technologies.[17] Their experiments with nature using various geo-engineering technologies to suppress the impact of climate change such as de-glaciation, sea level rise and hurricanes have the potential to decide whether to continue or drop the plan to invest in proposed technological solutions. Nowadays, geoengineering technology is promoted as an instrument for achieving 'net zero' emission targets by mid-century.

Drivers for Geoengineering

A few countries believe that geoengineering is a significant technology to reverse climate change, as they will not be able to cut carbon emissions soon. Thus, they have permitted their researchers to run computer simulations and do outdoor experiments despite the environmental side effects it might produce.

Table 2: Identified drivers for geoengineering technology in India.

Drivers	**Details**
Political	Lack of governance before experimenting and deployment of geoengineering technology.[18]
Economic	Governments across the world and businesses are funding for CDR (Carbon Dioxide Removal), Solar geoengineering and more valuable solutions such as EOR (Enhanced Oil Recovery).[19]
Social	Lack of provision for public participation in geoengineering decision-making.[20]
Technological	Most of the proposed solutions are under testing phase and are highly promoted by stakeholders such as scientists, engineers and businessmen. [21]
Environmental	Lack of independent assessment of local/regional impact on the environment and no/rare disclosure of geoengineering research and open publication of results.[22]
Legal	There is no regulatory framework for geoengineering technologies and their impacts.[23]

[17] The Clique That Is Trying To Frame The Global Geoengineering Debate
[18] Geoengineering: Governance Before Research Please
[19] Bill Gates Is Throwing Away Money On Ill-Advised Non-Solutions To Global Warming
[20] European Eco Forum
[21] Engineering The Earth To Fight Climate Change
[22] Geoengineering: Parts I, II, and III
[23] Geoengineering The Climate

Reasons to re-think geoengineering

Learning from the geoengineering experiments conducted so far, some scientists are convinced that these are not ethical solutions as their long-term consequences on the climate could be unpredictable and extremely disastrous.[24] The proposed "techno fixes" will maintain continuity of our current socio-ecological risks and injustices caused due to carbon intensive production and consumption patterns. This will only push us away from achieving our target of keeping temperature below 1.5-degree by 2030.

Table 3: Identified barriers for geoengineering technology in India.

Reasons	**Details**
Political	While there is a need to focus on radical climate protection, geoengineering is not only uncertain in terms of its impact on nature and society but can also become a threat to national security and cause trans-boundary issues.[25]
Economic	Costs related to climate mitigation through geoengineering are uncertain and have continued to increase.[26]
Social	If geoengineering is seen as the way forward no further steps might be taken for actual reduction of fossil-fuel consumption. This will perpetuate these air, water and land polluting systems with continued injustice to indigenous communities and local populations residing in pollution hotspots.[27]
Technological	The efficiency of geoengineering technology is still under question and we do not fully understand the uncertainty and its potential negative impacts such as induced seismicity and CO_2 leakages at each stage of the process.[28]
Environmental	Geoengineering technology has potentially catastrophic impacts such as alteration in rainfall patterns, earthquakes and ocean acidification.[29]
Legal	Non-availability of sufficient data and site characterisation has made it necessary to advocate for an international ban on field experiments

[24] 20 Reasons Why Geoengineering May Be A Bad Idea
[25] Why Geoengineering Is Still A Dangerous, Techno-Utopian Dream
[26] Evaluating Climate Geoengineering Proposals In The Context Of The Paris Agreement Temperature Goals
[27] Pollution From Fossil-Fuel Combustion Is The Leading Environmental Threat To Global Pediatric Health And Equity: Solutions Exist
[28] Human Intervention in the Earth's Climate: The Governance of Geoengineering In 2025+
[29] Geoengineering: Parts I, II, and III

	and the use of geoengineering. Also, it is necessary to demand for a multilateral system of governance to monitor and enforce this ban globally like done by the HOME campaign.[30]

The above drivers and barriers for geo-engineering painted a picture of the gaps in responsible deployment of these technologies and its potential impact, which often remain behind curtains, and hence are neglected worldwide during its promotion as a climate change solution.

Proposed Alternatives to Geoengineering Technologies

Public and private money must not be invested for further research, field experiments and pilot projects into geoengineering technology, and the government of India should instead look for reliable alternatives. There are five basic alternatives to the proposed geoengineering solutions that need to be incorporated in the climate action plan of India for an effective, just and sustainable mitigation of climate change. They are as follows:

1. A rapid exit from fossil fuels and a democratisation of energy generation through 100 percent renewables. However, there are certain environmental risks due to renewable energy infrastructures such as hydropower projects, which can do more harm than good. Thus, solar and wind energy are the two best alternatives. Other proposed alternatives are hydrogen fuel and biogas, as they can be used for most practical purposes with high energy efficiency, and have potentially huge social, ecological and economic benefits.

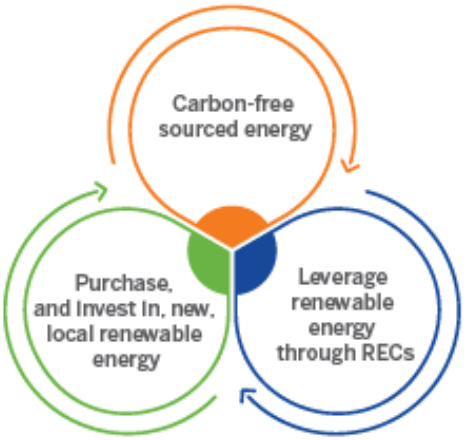

Figure 5: Action steps for achieving sustainable energy efficiency (source: IMA).

[30] An International Civil Society Campaign Against Geoengineering

2. A reduction in global energy and resource consumption through sustainable approaches such as conservation of energy at home and office, buying (if required) of only energy efficient electronics such as a fridge and washing machine and installing rooftop solar panels.

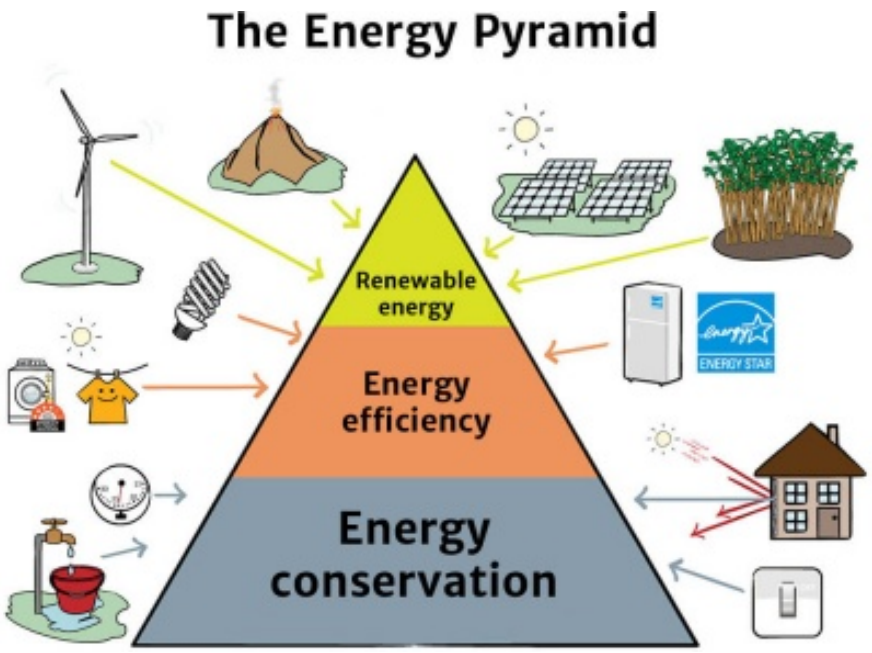

Figure 6: Energy sustainability pyramid diagram (source: Green Galaxies).

3. Economically marginalized communities suffer due to polluting industries, which affects their health and local livelihood such as fishing and farming. The women living in such communities are often oppressed by patriarchal and male-dominated power structures, and hence suffer even more due to lack of financial equality and leadership opportunities in mitigation of climate change. To confront this issue, there is a need to develop intentional pathways away from extractive economies by a just transition towards feminist and regenerative economy. This alternative economic model prioritises people and planet over profit, and recognises gender as a critical lens. Thus, it can shift India's current economic model that supports the privatisation and commodification of resources towards regenerative, sustainable, cooperative, and collective models, and prioritise women's leadership, gender justice, and human rights in policy-making and public discourse.

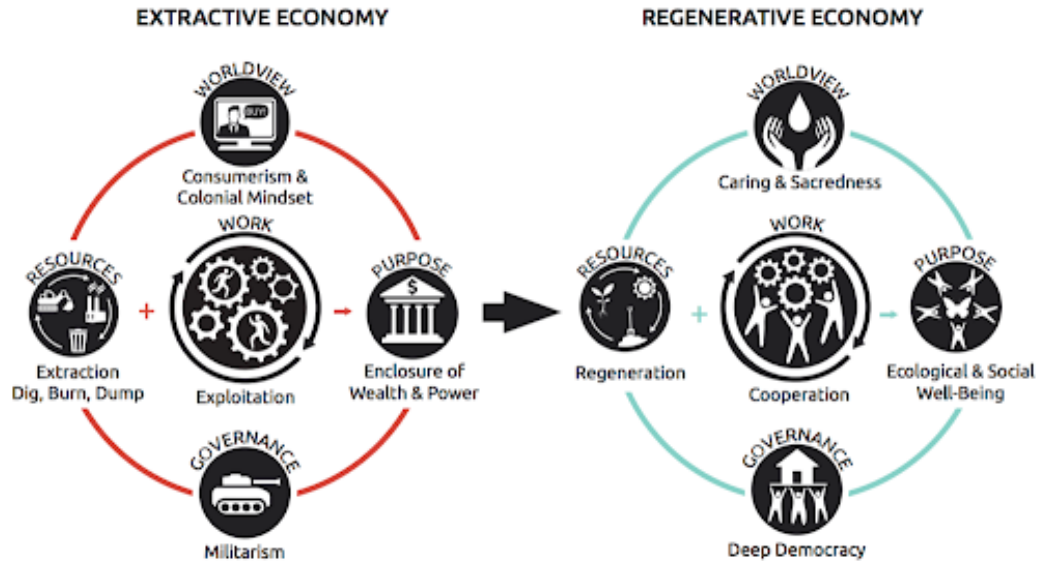

Figure 7: Just transition principles (source: Climate Justice Alliance).

4. A transformation of our food systems away from industrial agriculture and towards small-scale agroecological production systems by engaging the local and indigineous knowledge, especially that of women and youth could transform our food systems. Government and civil society should invest in agroecological research and ensure active involvement of farmers in the learning process to support agroecological practices and policies.

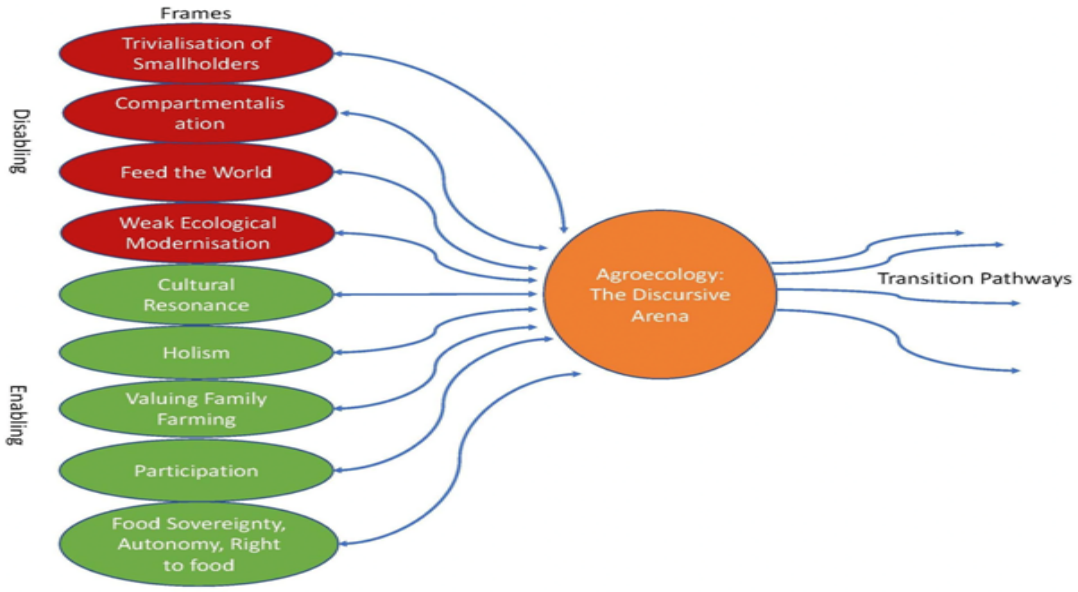

Figure 8: The nine primary frames for agroecology transformation (source: Food First).

5. A comprehensive and careful restoration of global ecosystems, especially forests, in which the rights of indigenous communities and local populations are safeguarded and strengthened. Since, the success and quality of the restoration depends on planning, implementation, monitoring and evaluation of restoration projects, the potential trade-offs of CO2 can be scaled up by undertaking effective and efficient activities which involve the local community in the restoration programs.

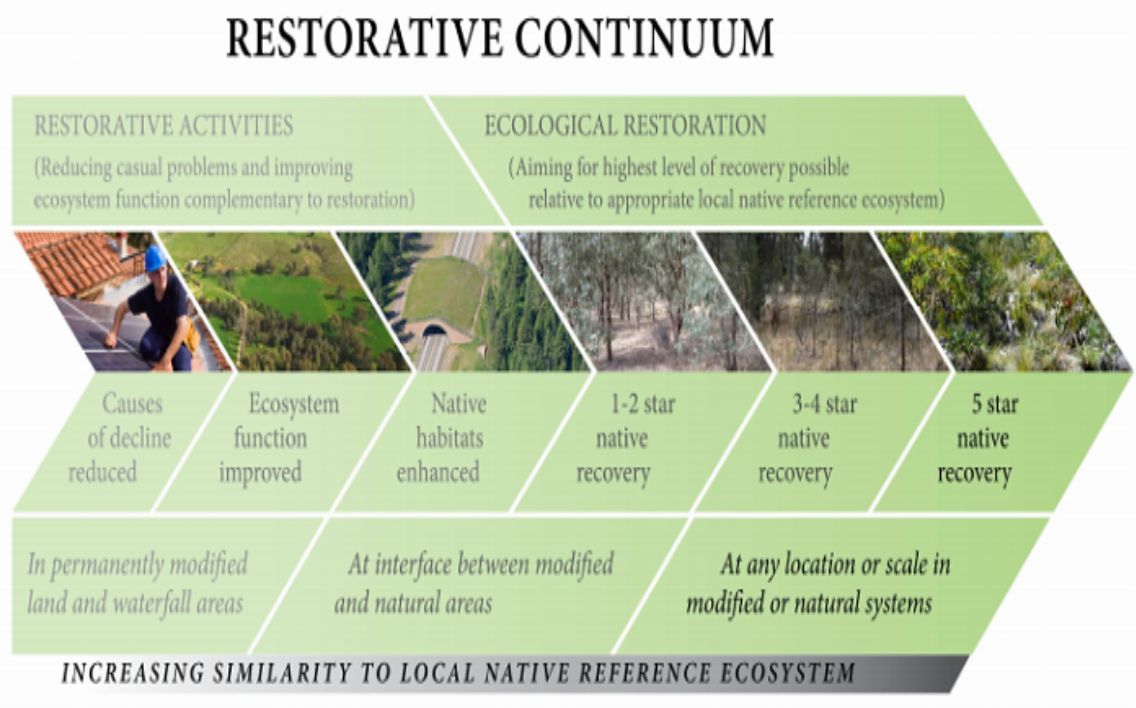

Figure 9: Activities undertaken by society to bring up ecological restoration (source: SER).

6. Prepare, implement and monitor a regulatory framework nationally and internationally for geoengineering to prevent its unintended effects on the climate system, ocean, biodiversity, ecosystem services and human well-being apart from the intended effect i.e., reduction of greenhouse gas reduction (see figure 10).

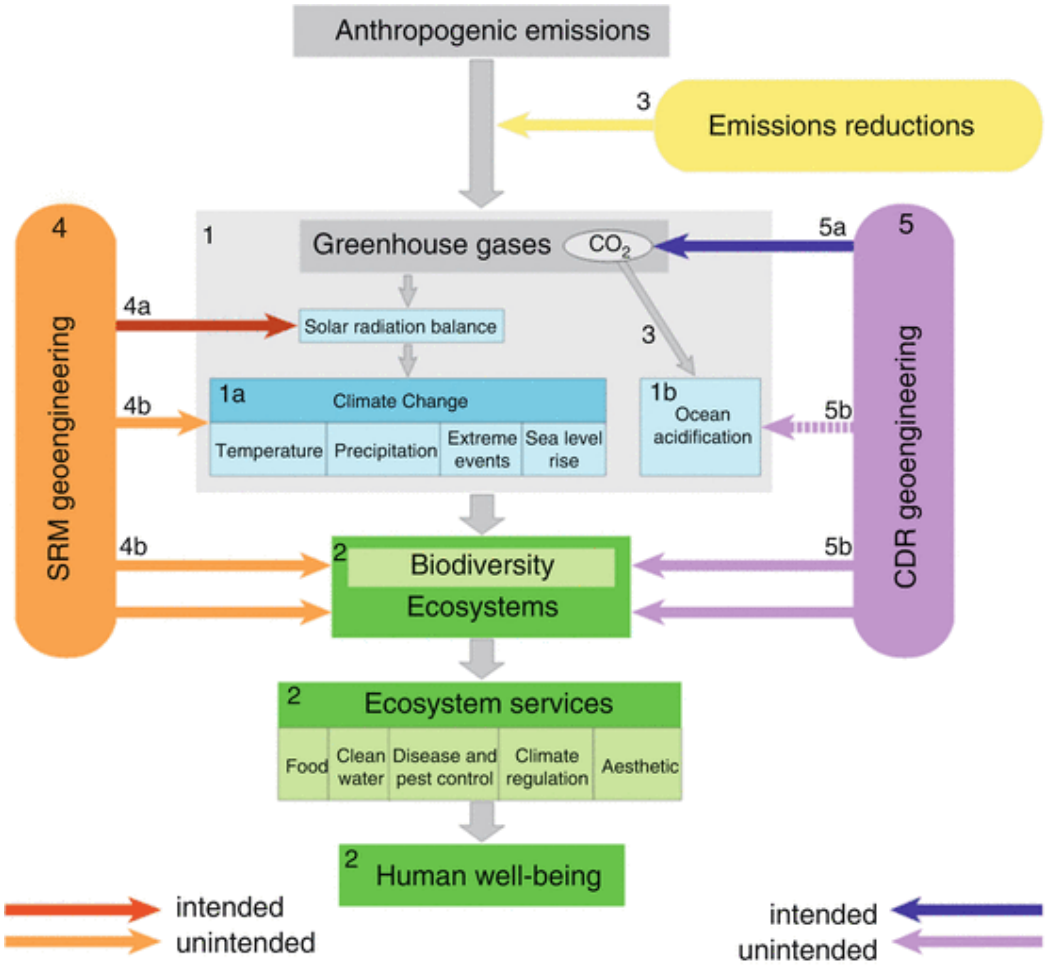

Figure 10: A conceptual overview of the effects of Sunlight reflection methods (SRM) and Carbon dioxide removal (CDR) techniques (source: Convention on Biological Diversity, 2012).

Conclusion

Almost all proposed geoengineering technologies have failed to stop emissions and our reliance on fossil-fuel, which cannot keep the world below 1.5 degrees. Thus, there is a need to discuss and understand all possible PESTEL (Political, Economic, Social, Technology, Environment and Legal) consequences of deploying untested technologies before bringing them to India. This will effectively reduce consumption of fossil fuels like coal, oil and gas and hence can make us go beyond the business as usual who's wheels are oiled by the unjustified geoengineering strategies.