Governance of Solar Radiation Modification: Developing the Pakistan Perspective

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**The views expressed by the authors do not necessarily reflect the official position or policy of their organization.*

Executive Summary

With global climate change impacts increasing year-on-year, discussions on Solar Radiation Modification (SRM) - deliberate, large-scale manipulation of the global climate system via increasing the Earth's reflectivity to sunlight, is gaining traction as potential mechanisms for delaying climate change. Much of the debate on proposed technologies to do this has occurred in the Global North, although the relevance for the Global South is very significant, and interest is growing there as well. The authors have been directly engaging with SRM in the context of the Global South since 2019, having participated in research, workshops, and other activities relating to the field's progression, while also maintaining science and governance work in climate and environmental issues of Pakistan. This policy brief is the result of a training workshop conducted in January 2024 in Islamabad, Pakistan, where the authors both spoke on SRM issues relating to the country's context. The authors outline the governance challenges associated with SRM, and provide an initial framework for Pakistani climate community members, civil society organizations, and policy and decision-makers to participate in the global discussions already underway on SRM. Finally, the authors have compiled recommendations on how the country should consider engaging with these upcoming climate intervention measures.

"India-Pakistan Border at Night" by NASA Goddard Space Flight Center

Setting the climate change context

The impacts of anthropogenic climate change are being felt across the world. Human activities, primarily through the reliance on fossil fuels and resultant greenhouse gas (GHG) emissions have led to a rise in global surface temperatures by 1.1oC since 1850. Approximately 42% of GHG emissions have occurred since 1990, highlighting how little has been done to curtail the sources of climate change. An estimated 3.3 to 3.6 billion people are highly vulnerable to climate change, with the majority of these people living in developing countries[1]. Many communities in developing countries are facing fast-onset climate impacts in the shape of floods and heatwaves, as well as slow-onset impacts such as droughts. This has repercussions in terms of their water, food and overall economic security. Moreover, it makes them less resilient to future extreme weather events, making them part of a vicious cycle which deeply affects their development trajectory.

In the context of Pakistan, the massive flooding in 2022 affected nearly 33 million people[2], and the economic losses were equal to about 8 percent of the country's GDP[3]. Understandably, development budgets in the country have been altered, and planned initiatives set aside to cater to the loss and damage incurred, as a result of the floods. The extreme precipitation seen during the 2022 floods was made more likely due to a changing climate[4]. Given Pakistan's extreme vulnerability to climate change, these floods are likely just the most recent example of the climatic challenges Pakistan will continue to face, with the costs of dealing with these climate impacts rising significantly in recent decades.

Climate negotiations are failing to deal with GHG emissions and temperature overshoot

Climate change first came onto the international policy agenda in the 1980s, with efforts from various environmental organizations leading to the recognition of this global problem. In 1992, the UN Framework Convention on Climate Change (UNFCCC) was promulgated at the UN Conference on Environment and Development at Rio de Janeiro. The primary aim of the Convention is to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[5] However, since 1992, the concentration of carbon dioxide (CO2), the largest contributing GHG in the atmosphere, has gone up from 357 ppm to 421 ppm in 2023[6], exacerbating the impacts of climate change across many countries. Further climate negotiations led to the Kyoto Protocol in 1997, with the focus on Annex-I (developed) countries to make concerted efforts to mobilize resources and reduce their GHG emissions as a way to address the growing crisis. That treaty failed to make headway once the US Congress did not ratify it, despite their economy being the largest contributor to GHG emissions, till then.

Discussions around a post-Kyoto framework revolved around the inclusion of non Annex-I (developing) countries in addressing the issue. This resulted in the Paris Climate Agreement in 2015, which aims to keep the global temperature rise to well below 2oC of warming, and preferably limited to 1.5oC. However, as per the latest analyses, the world is on track to experience warming between 2.5oC and 2.9oC by the end of the 21st century[7]. This has catastrophic implications for most vulnerable communities worldwide. Moreover, research continues to show that there is a high likelihood of breaching certain tipping points in the near term that will further stress the global climate system and

will exacerbate the climate crisis[8]. The worsening impacts will be in the form of accelerated melting of glaciers, changing of monsoons, and dying of coral reefs, to name a few.

Climate governance in Pakistan is challenging for multiple reasons

Pakistan is one of the most at-risk countries to climate change in the world[9]. Its high vulnerability to climate change is worsened by the plethora of governance issues that are making it difficult for the country to adapt to climate change. The 2012 National Climate Change Policy (revised 2021) provides Pakistan with a roadmap for tackling climate change across a variety of sectors in terms of mitigation, adaptation and the financing needed. However, it lacks a robust implementation framework since the country devolved the subject of climate to provincial authorities via the 18th Amendment to the Pakistan Constitution in 2010. As such, there is a lack of institutional structure that hampers the development of an effective climate response between the federal and provincial levels[10].

While the revised policy articulates a policy implementation mechanism by asking the federal and provincial authorities to develop action plans and be beholden to implementation committees that are to meet biannually, there is a power mismatch between where the finance flows from (federal level), and where the implementation needs to occur (provincial level). This dynamic of centralized-to-decentralized governance requires greater intergovernmental coordination and collaboration[11], as well as empowering provincial and sub-provincial levels with clarity on their roles, responsibilities and powers[12]. In all these aspects, there is a need for increasing the overall political stability of Pakistan's institutions to better address its climate governance challenges. Further complicating matters are various other cross-sectoral policies that deal with water, energy and food security that also need to be aligned with Pakistan's ambitious climate action plans.

In the aftermath of the Paris Climate Agreement, Pakistan prepared its Nationally Determined Contributions (NDCs). The commitments laid out in the NDCs highlight the mitigation and adaptation aspirations of the country, which are broadly contingent upon receiving international climate financing[13]. The current global climate finance model is struggling because developed countries have not scaled up financing for developing countries to the levels needed, and developing countries' capacity to vie for and absorb the financing has remained low, leaving climate finance a deeply uncertain prospect for countries like Pakistan[14].

The World Bank estimates that between 2023 and 2030, Pakistan needs US$348 billion in climate finance[15]; this financing and development gap is particularly problematic for Pakistan, where a significant proportion of climate finance goes towards disaster response through the National Disaster Management Authority (NDMA) and its provincial counterparts. While Pakistan does have an operational National Disaster and Risk Management Fund (NDRMF) that could address some of these needs, it is still in its infancy, having a financial portfolio of only US$ 420 million[16]. With a poor macroeconomic outlook and reliance on the International Monetary Fund for bailouts, Pakistan lacks the basic framework for addressing and developing local capacity to raise funds for the climate crisis. Although it has been able to tap into the Green Climate Fund (GCF) for six projects, compared to the country's needs, this funding is a drop in the bucket at only US$ 221 million[17].

SRM approaches are imperfect and have regional complexities

It is in the context of a rapidly worsening climate and its impacts of vulnerable populations that geoengineering (also referred to as climate intervention) - the deliberate large-scale manipulation of the global environment to counter human induced climate change, is gaining currency in some circles to address the climate crisis, particularly in the Global North. This includes carbon dioxide removal (CDR) techniques to remove CO2 from the atmosphere and Solar Radiation Modification (SRM, also known as solar geoengineering) techniques that reflect a small percentage of sunlight and heat back into space. While both CDR and SRM methods aim to reduce global temperatures, neither addresses the root cause of climate change, i.e. increasing GHG emissions in the atmosphere. There are also significant differences in terms of their modes of action.

CDR techniques include land use management to protect or enhance land carbon sinks, use of biomass for carbon sequestration, enhancement of natural weathering processes to remove CO2 from the atmosphere, and enhancement of oceanic uptake of CO2, for example, by fertilization of oceans with naturally scarce nutrients. Primarily, it is direct ambient air capture of CO2 that is gaining the most traction. These techniques require a large amount of resources and scaling in order to be successful, and are considered a long-term strategic option for reducing GHG concentrations in the atmosphere in addition to decarbonization.

SRM techniques directly manipulate the earth's radiation balance and, if implemented, would have a relatively immediate effect on the climate; they require limited technological innovation, likely achievable within a decade, and have a low, direct cost (e.g. between a few billion and tens of billions dollars per year)[18], as compared to the approximately US$ 1 trillion per year needed by developing countries to combat climate change by 2030[19]. Since these techniques act quickly and at global scale, proponents argue they could be potentially useful in alleviating some climate suffering, and help avoid reaching some climate tipping points.

Generally, SRM methods include increasing surface reflexivity of the planet by brightening human structures and marine clouds, planting crops with high reflectivity, covering deserts with reflective material, and placing shields or deflectors in space to reduce the amount of solar energy reaching the earth. The most widely researched SRM technique mimics the effects of large volcanic eruptions that inject aerosols in the upper layer of the atmosphere, called stratospheric aerosol injection (SAI). As compared to the other SRM interventions, SAI is considered the most robust at creating a global cooling effect, and the one this policy brief will focus on.

The enhanced concentration of reflective aerosols in the stratosphere would reflect a small amount of sunlight, thus reducing the radiation reaching Earth, resulting in a reduction in global average temperature, and potentially mitigating some impacts of climate change. While scientists have a high degree of confidence in how SAI will impact the average global temperature, there are significant concerns regarding potential unintended consequences in terms of other climatic factors like precipitation, as well as ecological and social aspects, particularly at regional levels. To date, there is limited research on various impact categories, much of it housed in the Global North[20].

Researchers have been considering various delivery mechanisms that could place reflective particles in the upper atmosphere. The most likely mechanisms for delivery of aerosols into the stratosphere

include a fleet of modified, high-altitude aircrafts, or high-altitude balloons. It is understood that SAI is technically feasible, including by a singular nation, a bloc of nations or even a private entity. Governance, monitoring, and backup delivery systems will result in the costs rising, but these costs will remain significantly low.

SRM does not return the climate back to its original conditions

Climate change is already resulting in hundreds of billions of dollars in loss and damage globally, and that figure is only going to increase[21]. The 2022 Pakistan floods are estimated to have cost the country over USD 30 billion[22]. In comparison, the costs to operationalize SAI globally may seem quite attractive to some, at only a few billion dollars per year. However, injecting aerosols into the atmosphere comes with its own major physical and social risks, same as climate change. Under the SAI scenarios currently simulated through the same numerical modeling techniques that project climate change, it is clear that SAI is not going to resolve the climate crisis, which can only occur with deep emissions cuts. Deploying SAI will create a new climate scenario, one that is distinct from the historic situation and from worsening climate change. The implication for consideration of any potential SAI deployment, therefore, is that risks associated with SAI must be assessed against the risks associated with worsening climate change, also known as risk-risk framing[23].

Current assessments of SRM find that while climate systems will respond quite quickly with respect to average global surface temperature, returning it to preindustrial conditions within a few years of deployment, precipitation patterns may not respond accordingly, and hence posit regional and global risks, particularly in the context of geopolitics and resource conflicts between communities and countries[24]. As such, deployment of SRM, and SAI in particular, is being presented as a last resort option in an emergency scenario where climate intervention may become necessary in the face of runaway climate change. Consequently, discourse on SRM research and potential deployment must rest on the principles of climate justice; understanding that SRM will impact the most vulnerable to climate change, those who have contributed least to its spread, and ensuring the protection of their basic rights and participation in decision making processes around these climate intervention technologies is paramount.

No matter if, when or how the decision to deploy SRM is made, it will end up being a multidecadal decision, so as to give time for continuing mitigation efforts, and to ramp up CDR technologies to remove the GHG emissions already present in the atmosphere. This adds another layer of complexity - of intergenerational justice, since today or tomorrow's society will be locking future generations into a dynamic they did not choose. Further, the fact that it would be a multidecadal deployment decision means that an excuse is present for delaying aggressive GHG emissions mitigation by those profiting from the carbon economy, such as fossil fuel companies. This is called the moral hazard, and is among the largest fears of those who are against even considering SRM as a potential stopgap measure for climate impacts. Therefore, any decision to move an SRM deployment agenda forward must make clear that mitigation remains the priority.

The levers of justice and governance are important to engage in the SRM debate, as they will signify how and what kind of decisions are made regarding research and potential deployment in our shared atmosphere. While the Global North has been investing in this space for more than a decade and a

half through workshops, conferences, reports, and projects[25], there is growing recognition that Global South participation is necessary to formulate a consensus around future SRM activities[26].

SRM governance as it stands today

Serious scientific research around SRM has been building since 2006, when Nobel Prize Winner Paul Crutzen broke the research taboo on the subject and brought SRM to the forefront of academic discussions[27]. While Global North institutions continue to lead the vast majority of such endeavors, expertise is developing in the Global South as well. Early efforts have also been undertaken to understand the governance aspects that pertain to research and potential deployment of SRM as well as the social, political and ecological bearings which will guide any eventual decisions in this regard.

Below is a non-exhaustive list of key developments in the SRM field that has relevance to governance considerations:

- The IPCC has discussed SRM in: Working Groups II and II of the Second Assessment Report (1995), Working Group III of the Third Assessment Report (2001), Working Groups II and II of the Fourth Assessment Report (2007), and Working Groups 1, II and III of the Fifth (2014) and Sixth Assessment Reports (2021/2022). The increasing attention to SRM by the IPCC is indicative of science policy shifting towards needing to better understand the risks and benefits associated with these technologies, and contextualizing their governance considerations.

- The UK-based Royal Society's 2009 report Geoengineering the Climate recommended the need for evaluating the viability of SRM technologies through international coordination and collaboration, and exploring governance dynamics at the international level.

- The Stratospheric Particle Injection for Climate Engineering (SPICE) program was launched in 2010 with funding from UK-based universities and research institutions to conduct small-scale outdoor experiments using high altitude weather balloons. However, SPICE was scrapped due to certain ethical inconsistencies found among some of the scientists working on the program after 3.5 years.

- From 2015-2019 China had an SRM research program worth approximately US$ 2 million that focused on policy and governance aspects of the field, with emphasis on modeling and impacts assessments.

- The US has seen significant activities around SRM, including two National Academy for Sciences, Engineering & Medicine reports published in 2015 and 2021 that recommended a transdisciplinary research program to reduce uncertainties in the scientific and social dimensions of SRM, alongside increased governance and public engagement. Further, the National Oceanic and Atmospheric Administration received US$ 22 million to study and model the stratosphere as part of its Earth's Radiation Budget research initiative.

- In 2021, the EU invested in two projects worth approximately US$ 14 million to assess a suite of sociotechnical pathways that included SRM technologies in achieving a zero-emissions future as well as the ethics and governance of such emerging technologies. In 2023, the EU approved a

3-year project to assess the conditions for responsible research in the SRM field called Co-CREATE.

- In 2022, the World Climate Research Programme initiated a task force to lay out the current SRM research landscape and devise a plan for how this intergovernmental agency can become engaged in future research efforts.

Notably, 2023 was a landmark year for governance developments in the SRM field, with momentum shifting as a result of global climate inaction. The major developments are listed as follows:

- In February, the United Nations Environment Program released a report titled One Atmosphere that contextualized the growing debate on SRM. The report argued that an international scientific review process was necessary to assess the risks and uncertainties of SRM and identify knowledge gaps, with efforts required to build governance processes that foster equity, transparency, diversity and accountability in decision making.

- In June, the announcement of a congressionally mandated SRM research plan by the US White House focused on advancing the scientific knowledge base, and concluded that outdoor experimentation could be on the table. The proposed research program highlighted the need for interagency coordination, and engagement in international cooperation, but did not clarify the scope or implementation mechanisms of such activities.

- Also in June, the European Commission/European Parliament issued a joint statement on the need for assessing SRM under the climate and security nexus, calling for greater research and deliberation on its risk aspects, as compared to the risks of climate change. In August, the Commission issued a scoping paper seeking the advice of its Group of Chief Scientific Advisors on addressing the risks and opportunities affiliated with SRM deployment as well as the governance systems needed to align it with the EU's other policies.

- In July, the United Nations Human Rights Council assessed the impacts of these climate interventions from the perspective of violation of fundamental rights to clean and stable climate, and called on nations to consider applying the precautionary principle, with reference to any potential SRM deployment activities.

- In September, the Climate Overshoot Commission, an independent body composed of former government officials, called for a moratorium on SRM deployment until inclusive research and governance frameworks are established.

- In November, the UNESCO World Commission on the Ethics of Scientific Knowledge and Technology published a report that highlighted the socioecological impacts of SRM, and called for the development of an ethical framework for governance on the basis of participation and inclusiveness and sharing of scientific knowledge and research between the Global North and South.

The wide ranging groups that developed reports and recommendations in 2023 is indicative of the growing interest in SRM as a consideration for potentially alleviating some of the impacts of climate change in the near-to-medium term. The principle conclusion across many of the activities outlined

above is that broader, more inclusive engagement and deliberation is needed, particularly for the development of governance frameworks on research. No actor is currently arguing for SRM deployment, but assessments have varied on whether and how outdoor experimentation may occur. Nonetheless, more research was encouraged, particularly impacts based work that brings regional and communal disparities under consideration.

Policy recommendations for governance of SRM in Pakistan

While Pakistan remains highly vulnerable to the climate crisis as recent episodes of flooding, heatwaves and droughts show, it has not yet taken the necessary steps to equip itself to effectively adapt to climate change. Policymakers remain unaware of climate risks, especially at the community level. As discussions around SRM continue to expand, Pakistan needs to develop a coherent stance on the issue and seek to actively participate in regional and global discussions on this issue. Currently, there is low awareness of SRM in Pakistan, and scant locally grown scientific initiatives that can inform policymakers. A broad based discussion around the issue needs to happen at both the federal and provincial levels, to determine whether SRM can potentially alleviate some of the climate burden currently facing the country and region. It requires resources to engage not only the local scientific community, but also the decision-making community that needs to operate up to the international level. Entities such as the Global Change Impact Studies Centre (the research wing of the Ministry of Climate Change and Environmental Coordination - MOCC&EC) need to develop an enhanced understanding of potential scenarios that may play out, if SRM is deployed. This information then needs to be integrated with the development of a risk profile of the country's most vulnerable regions and communities. Barring this, the issue will continue to be debated in and dictated from the Global North perspective.

Keeping that in mind, below are some critical policy recommendations that Pakistan should consider implementing with respect to SRM:

1. Operationalize the Climate Change Act and integrate SRM into the Climate Change Policy of Pakistan. The most relevant agency to deal with SRM, though articulated in the Climate Change Act, has not yet been established – the Climate Change Authority. By not operationalizing the authority, the execution of Pakistan's climate change policies relating to mitigation, adaptation and finance are continuing to be done on an ad hoc basis. The Authority would have the duly notified power to develop and amend climate policies as needed, including any deliberation and decision on SRM. It must be emphasized that integration of SRM into relevant guiding documents of Pakistan does not necessarily mean taking a favorable view of these technologies. Rather, the country needs to set a policy direction to determine how best to make decisions on SRM, now and in the future. Beyond the Climate Change Authority, the Climate Change Council of Pakistan and MOCC&EC are the relevant bodies to explore whether to engage in research on SRM, how best to set a national SRM research agenda and what research governance ought to look like, given global best practices and inclusive public engagement within the country. It remains imperative that Pakistan understands how SRM fits into the broader climate response portfolio and activities of the country, and maintains mitigation and adaptation as priorities.

2. Develop local, scientific and governance expertise on SRM. Awareness of SRM remains low in Pakistan, even among climate experts. In order to bridge this knowledge gap, in February 2023, MOCC&EC issued a directive to the major universities of Pakistan to engage in SRM research. Until now, COMSATS University Islamabad is the only research hub of Pakistan that is engaged in developing local, scientific knowledge on the impacts of SRM vis-à-vis climate change through internationally funded projects since 2020. Such efforts need to be expanded to include other universities in similar research work that will allow for the development of homegrown expertise. The Sustainable Development Policy Institute in Islamabad has hosted two engagement workshops and one panel discussion on SRM since 2011, where the primary conclusion has been that more localized impacts-based research would be helpful in establishing a national governance doctrine on SRM. Without a scientific base, development of governance will remain a challenge.

3. Ensure that key government institutions are keeping up and engaging with the governance activities at the international level. While discussions on SRM have yet to be broached directly at UNFCCC, the main international body dealing with climate change, governance activities at other international fora, such as UNEP, UNESCO and UNHRC, are paving the way for SRM discussions, particularly research governance. It is imperative that Pakistani negotiators from the Ministry of Foreign Affairs, MOCC&EC, Ministry of Planning, Development and Special Initiatives and NDMA are kept abreast of the rapidly evolving landscape of SRM within climate change. Representation at other climate meetings must be ramped up to a level similar to the UNFCCCs Conference of Parties in these various fora where the SRM issue is being discussed.

4. Actively seek to move deliberations on SRM to the regional level. Regionally optimized climate models are important for understanding how the overarching South Asian regional climate is affected, and how that may change the region's geopolitics under climate change and SRM. Specifically, shifting summer monsoon precipitation patterns and increasing glacial melt in the Hindu Kush Himalayas would be highly relevant for discussions around SRM. Under climate change, the Indus Water Treaty of 1960 between Pakistan and India is already coming under threat. Is it valid to assess whether different SRM deployment strategies may reduce or exacerbate tensions related to this treaty that safeguards Pakistan's major downstream water flows from India? Having robust knowledge of those impacts will yield more fruitful discussions with neighboring countries on how to proceed with governance. It also presents an opportunity for these countries to co-create research questions relevant to their regional climate context.

5. Develop country- and institutional-level guideposts/guidelines for SRM research and governance. Ethical frameworks for SRM research and governance are required to ensure that these activities are taking place in a safe, transparent, and accountable manner that drives from politically legitimate bodies. Under a top-down approach, going from the national level down to the institutional level, it is necessary to establish the overarching research themes and criteria for activities through public research programs that are accessible to the public, with mechanisms for civil society to challenge rules and procedures, as part of the policymaking process. Conversely, under a bottom-up approach, from the institutional level to the national level, it is necessary to establish research oversight and advisory committees that focus on the

processes of individual projects. At the forefront, it should be clarified if Pakistan is willing or unwilling to consider SRM experimentation beyond simple simulation work on its sovereign soil, and if so, what transparent and accountable measures are baked into the decision-making process that may serve as "exit ramps" when it comes to experimentation.

6. Support organizational and institutional capacity development that builds perspectives on SRM across different sectors. Same as climate change, any potential SRM deployment will impact different sectors. These sectors, like water security, human rights, food security, geopolitics, democracy, sustainable development, and business, will have diverging needs when it comes to understanding and participating in the decision-making processes around SRM. As climate change has become integrated across almost all sectors of an economy, there is a similar need to increase engagement on these technologies across all sectors to have truly inclusive deliberations on the potential for altering the global climate. The Alliance for Just Deliberation on Solar Geoengineering has a mandate to enhance the global dialogue on SRM following the principles of climate justice, and to facilitate knowledge and perspective generation in an unbiased manner that puts the onus on governments, civil society organizations and communities to collaborate with each other and ensure that decision-making on SRM occurs in a fair and balanced manner.

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