# Vanguard for a Blue Sky

Analysing Stratospheric Aerosol Injection and London's Climate Movement: An Ecological Leninist Strategy

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Abstract:

The world continues to boil due to capital's incapacity to resolve its climatic contradictions. Stratospheric Aerosol Injection (SAI), a technological process theorised to instantly reduce global temperatures, has piqued the interest of a now desperate ruling class. Given its worldwide impacts, enormous risks, and capitalist-imperialist reproductive capacities, it is crucial to engage with SAI while it is still in early development. Troublingly, there has thus far been little public consultation. In the UK, an emergent site of SAI development, the climate movement intersects at this critical juncture. The concern is that a historically depoliticised climate movement may uncritically accept SAI as a symptomatic fix to the crisis. Grounded in Marxist theory and departing from the conception of SAI as a spatiotemporal fix, this thesis addresses three primary objectives: assessing current perceptions of SAI among London's climate movement; evaluating the impact of political education in fostering a critical perspective of the technology, connecting this educational intervention to the Leninist concept of the vanguard layer; and considering how the vanguard layer can assist in counter-hegemonic struggle. The research involved a mixed-method qualitative experiment with members of London's climate movement. Findings reveal that while there is awareness of SAI's functionality, participants exhibited technological neutralism and misplaced optimism in liberal governance structures. This underscores the need for more critical education to challenge these perspectives. It likewise highlights the potential benefits of an ecological-Leninist approach to building a counter-hegemonic coalition of forces, capable of addressing the root cause of the ecological crisis.



**Key Words:**

Marxist-Leninist, ecological Leninism, stratospheric aerosol injection, solar geoengineering, spatiotemporal fix, counter-hegemony.

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## List of abbreviations

SAI – stratospheric aerosol injection

HSGRP – Harvard Solar Geoengineering Research Program

NASEM – National Academies of Sciences, Engineering, and Medicine

BECCS – bioenergy carbon capture and storage

IPCC – Intergovernmental Panel on Climate Change

IAMs – integrated assessment models

XR – Extinction Rebellion

CAs – citizens' assemblies

UK – United Kingdom

US – United States of America

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# 1. Introduction

The modus operandi of capitalism is to respond to crises through a repression of symptoms. The latest entry into this toolkit is stratospheric aerosol injection (SAI), a form of solar geoengineering (Malm 2022, 2). A technological process that alleviates spiralling temperatures through the release of reflective sulphate particles, SAI targets the symptoms of capitalist reproduction. Recognising the crises of capitalism's reproductive capacity owing to the crumbling environmental conditions on which it relies, capital is poised to pull the lever and initiate the dangerous process that cannot easily be undone (Buck 2019, 232).

SAI can be conceived as a spatiotemporal fix, temporally kicking the bucket of contradictions down the line to further legitimise green capitalist reformism and capitalist hegemony (Surprise 2018; Surprise 2020). Its Promethean capacity to instantly cool the Earth has, unsurprisingly, seen it gain significant interest in the capitalist core (Möller 2023, 22). This is especially true in the UK where research has ballooned, representing an emergent battlefield for the debate on SAI (Temple 2023).

On the flipside, marching against ecological collapse is the UK's climate movement, a mobilised force whose demands thus far have materialised few victories. Though mobilised, the movement is not organised in anywhere near the same capacity as capital, elucidated by an historical precedent of fractured analyses and depoliticised demands (Hestres & Hopke 2020; De Moor et al. 2020, 622-3; Marquardt 2020, 12; Kenis 2021, 140). Without sufficient critical analysis of SAI's capitalist defensive properties, its purported capacity to cool a boiling world may receive sympathetic acceptance from the climate movement. This perspective, even if acknowledging the need to reduce temperatures, may position SAI and the capital driving it as necessary in the context of a rapidly collapsing ecology (see Operaatio Arktis n.d.).

Grounded in Marxist theory, this thesis therefore has a threefold aim: 1) to understand how members of London's climate movement currently perceive SAI; 2) to discern the effectiveness of radical material in developing a critical purview, and more theoretically, conceptually relate this to the Leninist notion of the vanguard layer; 3) to consider how the vanguard layer might assist the climate movement toward counter-hegemonic ends. For the second and third aim, SAI acts

as a prism to investigate how the movement can be transformed into a radical actor via political education. This education comes in the form of a movement primer I previously cowrote with a youth-led climate organisation named Climate Vanguard. Two research questions are thus presented to allow for the exploration of this phenomenon:

- What is the reception of SAI among members of the climate movement in London, UK?
- How does the introduction of a critical movement primer, guided by principles of Leninist vanguardism, influence perceptions of SAI and contribute to the broader goal of transformative system change among London's climate movement?

This thesis fits neatly into the field of Human Ecology with SAI itself occupying the nexus of *culture*, *power,* and *sustainability*. The soaring temperature is a causal product of capitalist extraction, and the cultural framing of the problem is in constant renegotiation. The way SAI is perceived thereby reflects *cultural* understanding, constructed through ideology. Where the reality of the climate crisis has begun to threaten capitalist *power*, SAI is put forth as a temporary means to stabilise both the growing critique of the hegemonic capitalist system and save the planet from runaway temperatures for ecological *sustainability.*

SAI must therefore be analysed according to the power it reifies and be recognised as an artefact of modernity and technological optimism. Similarly, at this juncture of ecological breakdown, we bear witness to the growing struggle against the status quo. Herein this thesis aims to explore ways in which this counter-hegemonic struggle can be assisted and to build a strategy toward a transition away from capitalism. It does so through deploying a novel mixed method qualitative experiment, rarely seen in the field of Human Ecology. Owing to the pressing need to actualise systems change, this thesis aims to complement a panoply of research and strategies that might assist in the transition toward social justice and revolutionary ends. It likewise aims to fill an existing gap in the literature pertaining to public consultation and deliberation of SAI, supplementing the predominantly natural science deliberation of the technology, offering an intersectional analysis across discipline boundaries.

# 2. Framework of study

## 2.1 What is SAI?

SAI is the process of releasing aerosols into the lower stratosphere, forming a barrier that reflects some degree of incoming sunlight. It operates as a symptomatic solution, directly targeting the Earth's energy imbalance to cool the planet. In releasing greenhouse gases (GHGs), less heat escapes back into space thus increasing surface temperatures: global warming. The deployment of SAI aims at reducing this incoming sunlight, with less radiation entering our atmosphere the greenhouse heating effect is reduced (Crutzen 2006; WMO 2023). Importantly, it does not target the root cause of soaring temperatures and can be deployed without a reduction in $CO_2$ emission. Proponents of SAI however hold that the long-term goal of the process would be to buy time so that societies are able to decarbonise and sequester historic atmospheric carbon. This is referred to as "shaving the peak": deploying SAI in such a way that the worst calamities of rising temperatures are avoided whilst decarbonisation is undertaken, subsequently winding down the injections once atmospheric carbon is at an acceptable level (Buck 2019, 218-219).

The most researched deployment option for SAI proposes the use of high-altitude planes to release sulphate particles. The theory is based on a volcanic blueprint for temperature reduction. In 1991, the Mount Pinatubo eruption launched 20 million tonnes of sulphate into the atmosphere, cooling the Earth by half a degree for the subsequent 12 months (Malm 2022 12; IPCC 2013). The released particulate eventually fell back to Earth, and the cooling effect ended. SAI would thus require continuous aerosol injection to keep intact the planetary sunshade (NASEM 2021, 66-67; Smith & Wagner 2018, 5).

Current research leaves little doubt that SAI would have immediate effect, making it the only technology with the capacity to instantly limit soaring global temperatures (McKibben 2022). It is also relatively cheap. Suggestions fall in the several billion dollars per year region, markedly lower cost than a zero-carbon energy transition, or the price tag for no action at all (Ibid.; Smith 2020, 11; Smith & Wagner 2018). As for the delivery method, a specialised fleet of aircraft can be easily constructed on the basis of existing technology (Smith & Wagner 2018).

## 2.2 Literature discussion

### 2.2.1 SAI: unevenness

The origin of SAI is traced to Europe and the US (for a detailed historical account see Möller 2023, 21-33). However, its deployment will be anything but national. Integral to its effectiveness is its operationalisation as a global process, with the sulphate aerosols naturally spreading across the world's stratosphere. It fundamentally cannot be an isolated process, which brings us to the side effects of the technology.

Concerningly, a large body of scientific literature demonstrates myriad issues: ozone depletion (Tracy et al. 2022 5); a permanently white sky (Kravitz et al. 2012; Tang & Kemp 2021; Buck 2019, 223; Baur et al. 2023); uneven regional effects, including the weakening of monsoon seasons on which billions depend, and a global exacerbation of water insecurity (Liu et al. 2024, 1, 7, 9-10; Robock et al. 2013; Da-Allada et al. 2020; Yang et al. 2016); apocalyptic 'termination shock', unadaptable planetary roasting in the event of SAI cessation (Malm 2022; Malm 2023a; McKibben 2022); and computational limits in predicting global impacts (McLaren 2018; Biermann et al. 2022). The host of causal knock-ons is such that SAI cannot be conceived as a magical heat dial one might twist to restore our ecosystems to a pre-industrial state. Rather, it is a Promethean intervention that gambles with life on Earth.

Overlaying ecological issues are the technocratic limitations and global inequalities, positioning some actors as more able than others to participate in SAI modelling and research development (Buck 2019, 215, 221-3). Similarly, sustainable deployment of SAI is likely to be carried out by a powerful state or a cohort of allied states with the capacity to protect deployment. Restrictive access to this seat of the table therefore proves even more problematic for less wealthy nation states (Surprise 2020, 155; Posen 2003). In such a future, there will be winners and losers, flying in the face of climate justice (Szerszynski et al. 2013, 2812).

SAI is a symptomatic 'fix' to a colonised atmosphere. The trajectory of capitalist development, driven by the activity of a select few, has brought us to ecological ruin. Patching global heating by throwing other regions into disarray, predominantly located in the global South, will likely lead to a host of injustices and a reproduction of colonial relationships (Biermann et al. 2022).

### 2.2.2 Consent and legitimacy

Literature evaluating public opinion about and toward the use of SAI is limited. With that said, extant studies show that the public are generally uninformed and uncertain, a worrying finding given SAI's global scope (Asayama et al. 2017; Cummings et al. 2017; Carlisle et al. 2020). For there to be a legitimate geoengineered future, people must not only be informed, but empowered to shape our planetary future.

Troublingly, proponents of SAI have adopted a deterministic position, Horton and Keith (2016) claim that opposition to SAI "threatens to violate principles of justice by effectively condemning developing countries to suffer the consequences of activities of which they have not been the primary beneficiaries" (2016, 80). They likewise contend that mitigation and adaption will bear a greater cost for the poor, further justifying the development of SAI (Horton & Keith 2016, 81-3).

Addressed by Hordequin (2018), this invokes a paternalistic approach which seeks not to secure mass consent, but to act on behalf of others for the presumed benefit SAI is theorised to have. Through a lack of participatory consent and reflexivity, a mostly white wealthy US-based researcher corps risk parochialism by assuming universal acceptance of their views (Ibid., 279). Implicit is a pre-determination of what is fixed: accordingly, Horton and Keith (2016) hold that without SAI, the global South are condemned to bear the brunt of adaption; however, this need not be so. If climate justice mattered for richer countries, "they could transfer resources to poorer countries burdened with the costs of adaptation or could shoulder a larger proportion of the global burdens of mitigation" (Hordequin 2018, 279-80). Clearly this is not the reality in our current system, with climate reparations continually dodged. The precedent therefore makes it hard to imagine that the development and deployment of SAI will prioritise the interests of the world's poorest over the safeguarding of the richest (Ibid., 280). Such tendency would equate to a subversion of the imperial inequities paramount to the modern world system, and to the power balance that favours the richer countries from where SAI research emanates. Assuming SAI would be operated differently is to assume a change in the system that Horton and Keith (2016) deterministically hold as fixed and use as justification for deployment in the first place.

SAI parochialism has likewise already caused conflict. In June 2021, an SAI field research experiment by Harvard's Keutsch Group near Kiruna, Sweden was cancelled following protestation from the Saami Council. Interviewed on behalf of the Council, Vice-President Åsa Larsson Blind explained that the experiment was opposed because SAI "goes against what we believe." Specifically, the Council opposes "technologies that do not actually target the root causes of climate change," and that the solution to the climate crisis "is a change in societal structures" (Blind 2022). This continues to evidence the paternalistic nature of SAI development, especially in relation to Indigenous peoples who are already exceedingly vulnerable to the impacts of global heating (Rosqvist et al. 2022).

Surprise and Sapinski (2022) map this directly onto the funders behind SAI, finding that it is the philanthro-billionaire class, primarily from the technology and financial sectors, who are the main financiers of research. Labelled 'climate capital,' this group exploits the urgency of climate science to assert their dominance on the global stage as crisis managers. They constitute the driving force behind research and hold firm control within institutions like the Harvard Solar Geoengineering Research Program (HSGRP) (Surprise 2020; Surprise & Sapinski 2022). Leveraging Harvard's influence, the HSGRP utilises its convening power to orchestrate discussions among scientists, environmental leaders, and government officials regarding geoengineering (HSGRP n.d. a). Explored by Surprise (2020), this 'convening power' is deeply entwined with Harvard's legacies of liberal imperialism and its connections to centres of power within "finance capital, technology firms, military and intelligence establishments," that seamlessly integrate "into the structures of HSGRP" (2020, 157).

Climate capital's embrace of SAI must therefore be understood as a tactic by and for status quo reproduction. In this purview, though the HSGRP might claim that they do "not accept donations from corporations, foundations, or individuals if the majority of their current profits or wealth come from the fossil fuel industry," (HSGRP n.d. b) their support of a technofix to the crises of capitalism is supportive of fossil capital insofar as it does not challenge the root cause of the crisis.

Herein lies a fundamental problem, as we shall see, because the climate movement has historically operated from a reformist stance, a position that is sympathetic to a presumed neutrality of science and technology. Ignoring the epistemological boundary work of climate scientists could lead to an uncritical

acceptance of SAI among the movement, climate justice sidestepped, and a symptomatic fix hailed as triumph. This speaks to the justification for the first research question and where a gap in literature exists - what is the reception of Stratospheric Aerosol Injection among members of the climate movement in London, UK?

### 2.2.3 Universalising technological experience

In October 2022, then IPCC chair Hoesung Lee, delivered a speech declaring the IPCC as the "most powerful instrument to tackle climate change, a clear and imminent threat." Such declaration necessitates a universal experience of the climate crisis as not yet upon us, obfuscating the realities of already experienced climate disaster.

In conceptualising the crisis as soon to come, or as something we are facing as a universalised species, then "imaginings of apocalypse that escape specific culpability (for instance, in processes of settler colonialism, capitalism, or imperialism) and instead center a universal human frailty that ends with triumph, a clear moral, and a clean slate" can take hold of the climate debate, and sidestep climate justice (Gergan et al. 2018, 2). This can directly greenlight modernist ideas of technological climate fixes that primarily safeguard the climate and world that is beneficial to the capitalist system.

The IPCC has for a long time valorised negative emissions technologies to reach the goals of the Paris Agreement, especially bioenergy carbon capture and storage (BECCS) (Hansson et al. 2021). Concerning the use of large swathes of monocrop land to scrub carbon leads Ajl (2021) to question, "where BECSS will be sited in a world where national sovereignty and the national question are dismissed as irrelevant?" (2021, 53). Through its reliance on integrated assessment models (IAMs), the IPCC, and perhaps more broadly climate scientists, play a role in advancing what solutions are even on offer for the management of the crisis consistent with temperature goals (Beck & Oomen 2021). Consequently, by incorporating specific criteria and assumptions, IAMs wield substantial influence in shaping perceptions of an ideal future. Beck and Oomen (2021) assert that, predominantly, this desirable future is discerned through a cost-benefit analysis which endorses incremental decarbonisation of the free-market economy, thereby validating the existing status quo (Beck & Oomen 2021, 176).

Roos and Hornborg (2024) elaborate this point, questioning the Promethean valorisation of technology. Deploying a critical analysis of solar power, technological immaterialism and neutralism is shown to obfuscate the material extraction and political structures that make the technologies feasible. 'Technological immaterialism' here refers to the consensus with which "technology is understood as primarily ideas, blueprints, or designs," siloed from "wider environmental and social consequences and prerequisites," opposing such purview would be to recognise their dependencies on social metabolism (Roos & Hornborg 2024, 3; Hornborg 1998; Roos 2021). Similarly, 'technological neutralism' departs from the contention that technologies are "neither constitutive of nor constituted by social relations" (Roos & Hornborg 2024, 3; Ruuska & Heikkurinen 2021). To critique as much would be to identify a technology's social and political contingency, either as linked to "the political intentions of the owners or designers," or as necessitating and synergising with certain political relationships (Roos & Hornborg 2024, 4; Winner 1980, 123, 130).

Applied to SAI, these concepts can elucidate the ways in which the technology is political. For example, a material analysis would probe questions of where the resources to build and fuel a fleet of injection aircraft be extracted from? Or where the funding for the research originates? Likewise, in neutralising the politics of SAI, issues of governance and environmental suitability are glazed over. SAI will be operated by an actor(s) whose aim is to maintain a specific landscape, linking it with the political intentions of its designers and deployers. Indeed, the ultimate deployment of SAI is inherently an expression of capitalism, whereby carbon expulsion has led calls for such godlike intervention.

Such is the context of the current climate debate that probes the worry: if the debate continues to avoid challenging political questions, and a universalised battle against the climate crisis is imbricated into policy and technology, then SAI may well take hold. SAI does not have the capacity to positively transform the inequalities the climate crisis is necessarily interconnected with and must therefore be analysed with this in mind.

### 2.2.4 Theory of change within the climate movement

In recognition of ecological collapse, the climate movement has mobilised to urge decisive action (De Moor et al. 2020). Demands however have fallen at the wayside,

and mobilised action has achieved little tangible change. The potential reasonings behind this have been explored by a host of scholars and organisers alike, fostering the conclusion that the climate movement is divided in its positionality and tactics (Hestres & Hopke 2020).

Integral to this is the movement's theory of change, and the neutralisation of a political stance that can be found within. Heron and Dean (2020) stipulate that this has been tactically avoided by the mainstream contemporary movement, who often "deny climate change's true political consequences, guaranteeing that nothing essential has to change" (2020, 2). 'Tactically' in this instance being beneficial solely for the broad popularity of the organisation, Extinction Rebellion (XR) in Heron and Dean's critique. Referencing XR's cofounder, Roger Hallam's *Common Sense for the 21st Century* (2019), the authors take aim at the apolitical position put forth, a position that attempts to "shift the climate crisis from a *political* issue to a *moral* one," which they argue "conforms perfectly to the dominant ideology of our times: politics is bad because it is divisive, because it asks us to choose sides, to name our comrades and our enemies" (2020, 5).

XR has since slightly altered its stance. Now identifying as non-partisan instead of apolitical, one of their core demands remains that "governments must form citizens' assemblies and act on their recommendations" (Extinction Rebellion 2021). The citizens' assemblies (CAs) operate through the random selection of citizens representative of society at large. The assembly is then tasked with hearing from experts with alternative ideas, deliberating the issue at hand, and subsequently voting on recommendations.

Emphasis is placed on the independence of this proposed form of governance, with the process being overseen by non-governmental organisations that are "free from interference by government, corporations, or anyone else" (Extinction Rebellion n.d.). The issue, however, is in the audience. XR might strive to introduce a plethora of different ideas to the deliberation, but if the policy requires that capitalist democracy go beyond itself and dismantle fossil capital it is hard to envision its implementation by capitalist politicians. Though XR (2021) declares that its aim is to "persuade governments to act justly on the Climate and Ecological Emergency," its strategy would inherently operate within the capitalist parameters of what these measures could possibly entail. XR can therefore claim to be non-partisan at the scale of the capitalist social democracy system, but in failing to name

the driver of climate breakdown as capitalist metabolism itself, a position addressing the root of the crisis fails to materialise.

A temporary assembly where external economic interests are supposedly kept at bay is not then itself challenging of an entire economic order built on capitalism, carbon infrastructure, and global inequality. This reality will not cease to exist the moment one steps into the assembly, and thus the economic and political cannot and should not be separated (Berglund & Bailey 2023, 1017). In attempting this faux separation, the cultural hegemony which has cleansed and repackaged ruling ideas as common sense is overlooked. Participants of the CAs will harbour different ideas nested in divergent material interests, but common sense understanding will undoubtedly be shaped by capitalist ideology. Many CAs also emphasise reaching consensus, a problematic focus insofar as they operate on the assumption of full representativeness, and thus quantifying approval under such pretence "works to construct disagreement in the process of deliberation as a temporary and unfortunate hindrance," rather than allowing for the exploration of diverse perspectives (Machin 2023, 861, 857). Failure to comprehend the divergent historical material realities of the crisis thereby builds toward a goal-based narrative that valorises scientific solutions.

This is then representative of a reformist theory of change, one that has historically dominated much of the climate movement (De Moor et al. 2020, 622-3; Marquardt 2020, 12; Kenis 2021, 140). Reformist theory, with its framing of the crisis as passive politicians failing to listen to the science, works well for spontaneous mobilisation; however, it is inadequate in formulating the necessary long-term support for social transition (Evensen 2019). To draw attention to the realities of the climate crisis, the strategy has historically focused on disruption of everyday life (De Moor 2020, 622). Noted by Malm (2023b), whilst understandable, the strategy has ignited anger toward climate activists and has alienated people with whom allyship could be built. Disruption instead centred on sustained, targeted action that can apply pressure on the elites is historically shown to be more effective (Young & Thomas-Walters 2024).

With that being said, the arsenal of tactics deployed by the climate movement in recent years has grown. The likes of art 'vandalism' (Jones 2022); SUV tire deflation (Gayle 2022); and more militant action such as that against pipeline construction in British Columbia (Cecco 2022). Despite an expansion of tactics, the

movement appears smaller and more fragmented than it was pre-covid. In this lull, there arises the need to rebuild toward a stronger and more demanding united front, featuring radical theory to guide praxis (Malm 2023b).

The natural follow-up question then is what steps are to be taken? To develop a strong counter-hegemonic position, imperative is the interlacing of anti-capitalist, anti-imperialist theory within the climate movement and its demands, so that we can identify and reject techno-fixes, reject the apolitical nature of universalised technology, and instead bring about radical just change on an increasingly limited temporal scale. The introduction of counter-hegemonic theory provides the tools for guided practice to develop transformative praxis. Hence the second research question, an investigation into what this might look like. A starting point can be found in the rich theories of ecological Marxism, and the transitionary history from within ecological Leninism.

## 2.3 Theoretical framework

### 2.3.1 Ecological Marxism

This thesis analyses the intersection of SAI and the UK climate movement using an ecological Marxist framework. Accordingly, the SAI debate is situated in a specific historical materialist context, that being the UK, a neoliberal state adhering to and upholding the capitalist global economic system. Ecological Marxism is helpful in that it unpacks why capitalism specifically leads to ecological ruin and can thus expand for who and why SAI is particularly attractive as a symptomatic fix in a warming world.

Ecological Marxism contends that capitalism leads to metabolic rifts through its separation of worker from means of production, first observed with the degradation of soil. The spatial relocation of nutrients from the rural into urban centres disrupted the natural cycle and prevented nutrients returning to replenish the soil (Foster 1999 370). The metabolic rift has since been expanded to include the biosphere: incessant expansion of capitalist production frontiers culminating in greater atmospheric carbon, exacerbated by the depletion of natural carbon sequestering landscapes - greater carbon input into a system with fewer carbon sinks (Clark & York, 2005 408; Surprise 2018, 1231). This matters to capitalism because the system is imbricated and reliant on nature as a background condition.

Developed by Fraser (2017) as an expansion of Marx's conditions of capital, the background conditions unveil a growing crisis for capitalism. Fraser reasons that the conditions which allow for the reproduction of capitalism are as follows: political legitimacy, social reproduction, racialised and colonial expropriation of time and labour, and the Earth's resources; all of which must remain in operation for system reproduction (2017, 146-52). These tenets, however, possess independent logic that exists outside of capitalist logic. In other words, and focusing on the ecological, whilst capitalism is made possible using Earth's resources as commodities to fuel untethered capital accumulation, Earth's ecosystems in terms of their capacity as both an input and a sink for this production is at breaking point – "the serpent tends to eat its own tail, cannibalizing the natural conditions on which it relies" (Fraser 2022, 118). Nature is thus constitutive of capitalism's existence, and yet the system leads to the collapse of the prerequisite through the economising and underproduction of it – the underproduction crisis, also termed the second contradiction of capitalism (O' Connor 1998, 181-2).

Struggles with the independent logic of nature has long plagued capitalism. The ecological Marxist concept of *real subsumption of nature* is a useful tool to unpack this. Subsumption is classed as formal when it does not impose absolute change in the labour process, essentially the appropriation of a process that existed before the interference of capitalist logic (Mau 2023, 234). A precarious position for capital, without change to the organisation of the production process, said property relations can be dissolved through resistance, and capital repelled without need for broader reorganisation (Mau 2023, 234-5). Capital's position becomes more entrenched, however, when subsumption becomes real: the radical altering of the "social and technological conditions" of the labour process, a siloing of production processes for example. It is through this transformation that the creation of surplus value and the manufacturing of raw material into use value become enmeshed, and capital as a social form materialises (Ibid.).

Ecological Marxism expands classical labour subsumption to include nature itself. Capital must contend with the logics of nature which contradict the principle of constant production. Where before capitalists were hampered by the natural limitation to the input of energy into their production, so emerged fossil capital to disconnect industry from the hydrological cycle and its water wheels, provisioning factories instead with a constant flow of energy (Malm 2016). Factories were thus

free to move to areas of labour abundance and – upon acquiring a supply of coal – produce commodities around the clock. This transition is representative of the real subsumption of both nature and labour, such that production now exists in abstract time toward a state of perpetuity, siloed from the natural logics of limitations.

Capitalism has been historically successful in this pursuit, but now faces its greatest obstacle yet: atmospheric carbon. The runaway train of rising temperatures threatens sites of production along the coasts, worker productivity in heat stressed conditions has dropped, and global trade interrupted (Rojanasakul 2024; ILO 2019; Mooney et al. 2023). The vice is tightening, and the death knell sounded by neoliberal entities concerned with threats to their system of subordination, coldly conflating the conditions of capital with the good life (Ajl 2021, 24). From both the purview of the environmentalist and the neoliberal concerned with economic health, a crisis of underproduction is swelling.

Applying this theoretical framework to SAI unveils capitalism's motive, a capacity to subsume nature further. Through meddling with stratospheric chemistry, alleviating the tension of a crumbling background condition through the deceleration of meltdown, SAI acts not as a tool to open new frontiers for production but to protect the status quo. A measure to delay ecological breakdown and re-legitimise green capital transformation.

### 2.3.2 Green capitalism's crisis of time

Another necessary buttress of capitalist hegemony is sociopolitical legitimacy. Far from faceless, it is a system upheld by capitalist states, their constitutive public powers, and by extension broad support of the citizenry (Fraser 2022, 12-3). Within this context we see political struggle over crises: the "'ecological crisis' is as much (or more) a political and ideological category as it is a scientific construct" (O'Connor 1998, 137). Through the systemic underproduction of nature there builds the climate crisis, which, as noted by Surprise (2018), is in turn marked by the "political struggles over the ways in which climate change is understood as a crisis for capital and strategies are being devised for its management" (2018, 1232). Concretely, as the reality of the ecological crisis worsens, so too grows political struggle over how and who manages it. The growing support and resistance of the climate movement represents a contention, one that risks the loss of political

legitimacy if capital is seen not to be addressing the concerns of the public. To therefore protect capital, strategies of management have been offered.

Green capitalism has been the hallmark of neoliberal climate management. The precedent purports 'solutions' to the problem that protect business-as-usual: corporate social responsibility, carbon pricing, cap-and-trade, electric vehicles, green consumerism, all false fixes that open new avenues of capital accumulation (Akbulut 2019; Brand 2016; Gunderson et al. 2020; Mahnkopf 2016, 143-4; Surprise 2018, 1233;). These strategies do not alter the power balance within capitalism, rather reinforce its legitimacy through a strategy of reformism that positions capital elites as managers of crisis (Gorz 1967, 6-7).

Countless critique has been mounted of green capitalism, ranging from its reproduction of extractive practices to its reliance on mythical technologies (Dunlap 2021; Hickel 2019; Vadén et al. 2020). Importantly however, even if one does have faith in the gradualist change toward a 'sustainable' form of capitalism – a questionable position in the absence of evidence for the decoupling of ecological breakdown and endless growth (Jackson 2016, 102; Kallis et al. 2020, 10, 110; Vadén et al. 2020;) – then the key is time. Green capitalism necessarily relies on slow change to preserve capital's power and to invent new technologies. It requires a transition to renewable energy and a sequestration of historical carbon. This takes time, and time is not the ally of crisis. As temperatures soar, capital's background conditions of nature and political legitimacy fall more quickly. The vice tightens further.

### 2.3.3 Spatiotemporal fixes

Harvey (2007) developed the idea of a spatiotemporal fix as the strategy through which capital delays its first contradiction, the overaccumulation crisis. Capitalism, premised on the continual reinvestment of surplus value to increase productive capacity, eventually reaches a point where reinvestment no longer produces increased returns. In turn, the market and existing production landscapes becomes devalued through excess capital and dearth of demand (O'Connor 1982, 162, 182; Harvey 2007, 2017). Via the investment of surplus into new 'untapped' geographical areas, the re-entry of capital value is deferred: spatially displaced and temporally relocated, securing surplus extraction well into the future (Harvey 2017, 64-5). Landscapes are therefore transformed to delay the internal contradictions,

*delay* being the operational word with the root cause of the contradiction remaining unaddressed.

Ekers and Prudham (2015; 2017) expanded Harvey's concept to include the underproduction crisis too. Focusing not only on the economic expansion of fixed capital as in Harvey's (2007) definition, Ekers and Prudham contend that spatiotemporal fixes have an ecological angle, insofar as the expansion into new spaces inherently transforms "socionatures" (2017, 1384). They find that capital is responding to the underproduction crisis and interconnected social pressures by employing socioecological fixes to accumulation processes; however, these can and often do amount to greenwashing, the directive only to reproduce capital accumulation into the future (Ekers & Prudham 2017, 1385).

With that expanded definition in mind, Surprise (2018) applies the concept of the fix directly to SAI. In its potential to defer the onset of crisis "through the production of atmospheric space," SAI represents a unique global application of a fix through temporally "elongat[ing] the timescales within which green capitalism proves effective" (Surprise 2018, 1239-40). Nature thereby becomes further subsumed, and the crises of underproduction and associated political legitimation are deferred. In this understanding, SAI as a spatiotemporal fix could soon be deployed, not to open new frontiers for accumulation as in the traditional understanding of the fix but to protect contemporary accumulation and capitalist landscapes (Surprise 2018). Passive revolution, from fossil capital to green capital.

This theoretical framework has so far been concerned with the ways in which capitalism survives to underline capital's advanced capacity to – albeit temporarily – deal with crisis and transition. It is here that the theory turns now to address how we on the left might act at this juncture, and to instead build toward our own transition away from the oppressive status quo.

### 2.3.4 A transitionary theory

We are faced with a temporal crisis, both capitalists and environmentalists alike. For capital, SAI may delay crisis onset, and for those of us in the climate movement, we are in need of a theory of change capable of working on the relevant timescale to avert further catastrophe. In his book, *Corona, Climate, Chronic Emergency: War Communism in the Twenty-First Century,* Malm rightly asserts that social democratic slow reformism is not compatible with the urgency of the ecological

situation (2020, 120-1). Instead, Malm argues that what is required is swift nationalisation, expropriation of wealth from the elites, and the use of coercive state power to stand any chance of escaping ecological ruin. This ultimately means "turning the crises of symptoms into crises of the causes," representing an outline for the demands of a counter-hegemonic movement (Malm 2020, 148).

For the realisation of this strategy and to answer the contemporary question of what is to be done, ecological Leninism provides a host of experience, locating the struggle for transition in the political will and organisational capacities of us on the left of the climate movement. It should be underscored here that the rich depth of ecological Leninism is not delimited to Lenin himself but is interrelated and expanded by other struggles. Lenin's work, *Imperialism, the Highest Stage of Capitalism* (2010 [1917]), highlights how capitalist expansion of frontiers ultimately leads to imperial colonial rule. However, it is in the elaboration of this thought that tangible struggle has taken place, namely from anticolonial thinkers such as Fanon who asks that we "stretch" Marxist-Leninist analysis for their application in anticolonial struggle (Fanon 1963, 40). Ecological Leninism is not therefore to be read as blueprint for the duplication of tactics in contemporary contexts; rather, it ought to be applied with appropriate change dependent on the historical context within which transition is required (Le Blanc 2023).

The struggle against ecological ruin necessitates we all participate in the struggle of our time and rise to the challenge of "transitional thinking and acting" (Heron & Dean 2022). Concretely, this requires strong anti-capitalist and anti-imperial principles, guided by theory and education to unite the globally oppressed against oppressive systems (Le Blanc 2023, 180). Such is the crux of the work and where the concept of Lenin's *vanguard layer* can be applied. The *vanguard layer* refers to a class-conscious stratum of the global majority whose goal is to educate and guide the masses toward a strong counter-hegemonic position. Anyone among the global majority can develop this consciousness; however, currently this portion of the majority is a minority within, and it therefore must not,

> substitute itself for the majority (let alone arrogantly claim that it *is* the majority). Rather, it must seek to win more and more individuals, more and more of the majority, to forms of consciousness and activity through which they too will either become part of the vanguard layer or increasingly

> conscious and active supporters of what that layer is reaching for (Le Blanc 2023, 181).

It is sometimes presented that Lenin was attempting to introduce a form of elitist intelligentsia to do the thinking *for* the majority (Scott 2020 [1998], 150-1, 154). Counter to this, Le Blanc (2023) contends that, "Lenin's actual point is that one cannot assume workers will spontaneously be either pro-socialist or pro-capitalist," rather, workers may lean more toward reformist ideas to improve wages and working conditions, without necessarily adopting socialist ideology. A focus on the symptoms of capitalism rather than the system as root cause. Lenin emphasised the importance of distinguishing between the current state of affairs and the future potential of the labour movement. He did not see the labour movement as determined solely by objective economic forces or doomed to be influenced by bourgeois ideology. Instead, he advocated for an active intervention from the class-conscious layer to promote socialist consciousness and revolutionary praxis within the labour movement. Not to dictate action, but to assist the working class to understand and embrace socialist ideas as part of a broader movement toward revolutionary change (Le Blanc 2023, 20-1; Suny 2020, 137).

I will now briefly detour to consider a chief Leninist transitionary tool, that being the *vanguard party,* and its differentiation with the *vanguard layer*. The *vanguard layer* does not stand outside the majority but is rather a layer *of* the global majority. It is therefore constitutive of the globally oppressed, and not representative of external rule. A *vanguard party* may only be deemed vanguard if, "its orientation is embraced by the *broad vanguard layer of the working class*" (Le Blanc 2023, 21-2; Molyneux 1978). It is therefore possible to talk of the work of the *vanguard layer* without explicit consideration of the *vanguard party*, the growth and formation of the former necessarily preceding the latter. Figure 1 demonstrates this relationship.

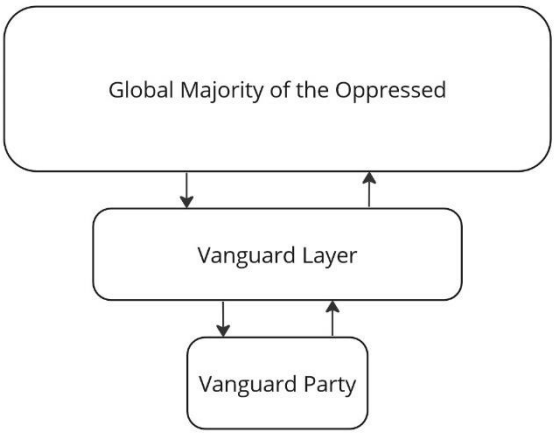


*Figure 1 The global majority, vanguard layer, and vanguard party relationship.*

The *vanguard party*, when operating effectively, does not seek to impose its will upon the masses but rather acts as a catalyst for their self-emancipation. The role of the party is therefore not to dominate, but to educate, organise, and empower the global majority to become the architects of their own liberation. Central is freedom of discussion, transparency, and democratic election as was seen in the Bolshevik's party congress (Le Blanc 2023, 52-3).

Though beyond the scope of this thesis to consider explicitly the building toward a vanguard party as a transitionary method, it bears touching on the debate. For Heron and Dean, a party represents a "form of political organization that endures, scales, supports a collective consciousness, and enables coordinated action," with a capacity to "see from larger perspectives: the national, regional, and global" (2022). To its credit, the history books demonstrate the success of the party in Russian's Revolution. However, valid critique can be found, including that from Lane (2021) who contends,

> class groupings, economic and political structures and cultural levels are totally different from those of Russia in 1919. On such a stage, the transition to socialism takes place under quite different and more challenging conditions than those known to Lenin (2021, 471).

A concrete analysis of concrete conditions is therefore integral to any party building.

This thesis sits in an overlap of shared consensus between both those who do or do not see hope in the vanguard party format. For both sides, imperative is the building of movement organising through radical education and good praxis, a

development of a broad vanguard layer to intuitively respond to shared struggle in a principled and socially just way. Facing against the globalised world of today, a requirement is in the understanding "of the contradictions of an increasingly coordinated global capitalism with strongly integrated economic, media, ideological and political elites," with Lenin's "analysis of class forces and alliances as movers of social change, in the role of media to influence and change people's political awareness, and in the territorial divisions of classes" providing theoretical guidance (Lane 2021, 470-1). Without as much, "demands for civil rights and justice by contemporary social movements are not calls for the installation of socialism but for a more acceptable liberal democratic version of capitalism" (Ibid., 461). Similarly, for those advocating party formation, the vanguard layer must chiefly support a "shared understanding of where we are and where we need to be, and a recognition that we can only get where we need to be through organized, collective action" (Heron & Dean 2022). Whether or not you stand by the need for party formation to act as the next transitionary step, a prerequisite for any transition is political education and movement organising against capitalism.

Therein lies the current strategy for Climate Vanguard, a youth-led organisation empowering the climate movement through political education. One of the core aims of this thesis is to assess the impact of a forthcoming movement primer written on SAI. In increasing literacy of the technology, the primer is intended to assist the climate movement in formulating a position. Climate Vanguard's work could therefore be conceptualised to comprise that of individuals within the vanguard layer, working toward ecologically sound and revolutionary ends – ecological Leninism in practice. To assess the efficacy of this, a novel mixed method experimental research design was deployed across two sequential sessions.

# 3. Research design

## 3.1 Methodology

This research was conducted within the tradition of critical realism, a philosophical framework marked by three core principles: 1) the embracing of ontological realism, a recognition of the existence of an independent world beyond individual interpretations; 2) epistemological relativism, acknowledging that our understanding of reality is shaped by our perspectives and methods for uncovering such; 3) an emphasis on judgmental rationality, advocating for informed judgments based on evidence and reasoning, even as the limitations of human knowledge are acknowledged (Bhaskar 2010, 1).

Central is the concept of ontic distinguishment, which delineates between the domains of the *real*, the *actual*, and the *empirical*. The *real* denotes the existence of objects with inherent structures and causal powers, irrespective of our comprehension. When these powers are activated, they manifest as the *actual*, tangible expressions that drive events and phenomena. Meanwhile, the *empirical* realm encompasses our human experiences of the *real* and *actual*, even when these structures are not directly observable. This perspective allows for observations of empirical effects to elucidate the existence of unobservable objects (Sayer 2000, 11-2). Critical realism is thus concerned with abstraction that can be observed only through mediated observation. The causal principles of this thinking therefore do not contend with the empirical regularities of social phenomena but aim to tease out the causal mechanisms that situate specific events within historically situated contexts through research (Bhaskar 1986; Sayer 2000, 14-5). This thesis, in addressing the socioeconomic dynamics of SAI, capital and the climate movement, makes critical realism with its ontological depth an appropriate choice.

The critique of positivist objectivism and apolitical technology claims that runs through this thesis is likewise consistent with the critical realist paradigm for scientific truth and knowledge itself is imbricated within power relations. Knowledge is therefore situated, and claims of objectivity are false, alternatively referred to as the "ontic fallacy" (Bhaskar 1986, 253) Knowledge should thus be understood as fallible, and whilst some theories are closer to true reality, it is a mistake to assume all knowledge is not conceptually mediated by the investigator

(Guba & Lincoln 1994, 110). A critical realist approach therefore allows for an analysis of reality that considers things only as the way they are because of the exercising of certain powers, and the repressing of others. It is thus crucial for a theory of change insofar as what entails the reality in the contemporary context does not necessarily make it the reality in another context should causal structures be altered, therefore positioning critical realist analysis toward emancipatory potential (Bhaskar 1986; Sayer 2000 18-9)

## 3.2 Method

### 3.2.1 Sampling

I crafted a survey to derive basic qualitative data on SAI literacy, and to sample participants from London's climate movement (see appendix A for survey questions). This was circulated in two ways: through posting to the public social media pages for organisations including Extinction Rebellion, Fridays for Future, and Greenpeace. Other organisations with more restrictive access were contacted through personal connections and via the snowballing technique whereby respondents subsequently shared the survey within their respective climate organisation circles. This enabled the survey to be shared with closed groups, including Fossil Free London, Just Stop Oil, Stop Rosebank, Tipping Point UK and Green New Deal Rising. Two other organisations were contacted via email - Resilience Project and Force of Nature.

The circulating of the survey was extensive but not exhaustive. There are undoubtedly climate organisations that the survey did not reach; however, extensive effort was made to share the survey and pool participants from across London's climate movement. This resulted in 73 responses.

16 respondents to the survey indicated an interest to participate in the research. These were contacted, with nine replying. Due to unforeseen circumstances, four of these nine were no longer able to participate, the remaining five becoming the participants for the sessions. A slightly higher and equal number of participants would have been preferential to increase robustness of the results; however, sufficient data was collected to answer the research questions.

The table below presents the participants involved in the research, the climate organisation(s) they are affiliated with, and their respective experimental conditions (to be explained in due course).

| Participant | Affiliated Climate Organisation(s) | Experiment Condition Group |
|---|---|---|
| 1 | Green New Deal Rising | Intervention |
| 2 | Friends of the Earth; Fossil Free London; (unnamed) activist choir | Intervention |
| 3 | Fossil Free London; formerly Extinction Rebellion | Intervention |
| 4 | Extinction Rebellion; Fossil Free London | Control |
| 5 | Extinction Rebellion | Control |

*Table 1 Participant sampling*

### 3.2.2 Qualitative experiment

I conducted a mixed method *qualitative experiment* consisting of two focus groups, an interview, and a scenario exercise. These were split into two phases: the first phase included a pre-test focus group; the second phase included the scenario exercise, followed by a post-test focus group and interview. The qualitative experimental method offers a way to investigate intervention, in this case the movement primer, and explore more holistically social phenomena than a traditional quantitative experimental design would allow (Robinson & Mandelson 2012, 2; Canella & Lincoln 2004).

Participants were foremost asked to read and sign the consent form, available in appendix B. After which commenced the first phase focus group, wherein participants were probed on movement strategies, their visions for ecological transition, and their baseline perception of SAI. At the end of this session, to give all participants a basic overview of SAI, extracts taken directly from Wikipedia were presented for participants to read (available in appendix C). The decision to utilise Wikipedia for this overview as opposed to one authored by myself was made to avoid my own positionality on the topic creating a bias that could influence the

experiment. Wikipedia likewise has biases; with its content written by contributors whose own positionality remains hidden, the bias is unclear. However, Wikipedia is an open source and accessible to anyone in the climate movement. It is for this reason that the basics of SAI given to all participants was copied directly, mimicking information that could be accessed by other members of the climate movement outside of these experimental conditions.

I then randomly allocated participants, either control or intervention group, the former acting as the baseline and the latter to be compared to (see Table 1 above). The intervention group were given extracts of the movement primer, to be read before phase two (see appendix D for these extracts). In the second phase, the groups were split into their experimental conditions. Participants were given 35 minutes for the scenario exercise. After which, the groups were reconvened, and another focus group was held where participants from both the control and intervention group were asked to reflect on the exercise, their rationale, and what informed their decisions. Unfortunately, one participant from the control group fell ill and was unable to join. This meant that the second session consisted of four participants, one in the control group and the three in the intervention group. To work around this and to gather sufficient data for the control group, I repeated phase two with the participant, using a follow-up unstructured interview to explore the participant's rationale in place of a focus group.

Although the experimental quantitative nature of the study was important for understanding the causal effect of the introduction of the movement primer, equally important was understanding the mechanisms and structures behind the meaning construction for participants. For this reason, the research followed Creswell's dominant-less dominant design, a framework that includes techniques from different methodologies but remains broadly aligned to one in the data analysis stage (1994). In this case, a qualitative approach was dominant, with the quantitative experiment playing a supporting role. To do so, the different methods were integrated and embedded into the two-phased study, wherein both quantitative and qualitative data collection and analysis was concurrently implemented (Robinson & Mandelson 2012, 3; Creswell & Plano Clark 2017, 108).

Operating from the critical realist paradigm, the experiment itself can be understood as an event within the domain of the *actual*. The measured outcomes are therefore to be understood and explained by the structures and mechanisms

within the *real*, shaping the perspectives of the participants therein. Thus, the qualitative experiment method: qualitative techniques of interpretivist and dialectical focus groups or interviews, embedded within traditionally quantitative experimental conditions, with the aim of uncovering the effects of the intervention, what was influential, for who, and why (Creswell & Plano Clark 2017, 107-9; Robinson & Mandelson 2012; Steils 2021).

As a method it is not delimited only to focus groups, the planned choice to use these however was twofold. Foremost, with the research questions pertaining to the perception of SAI within the climate movement, meaning construction among members was of interest. In much the same way debates might be had within climate movement circles, the focus groups aimed to develop dialogical meaning construction. Second, the *why* behind the understandings and views held by different individuals is naturally probed by other participants, unearthing data that would have otherwise remained unfound in traditional one-to-one interviews (Bryman 2012, 503).

Ideally, all participants would have been present for both focus groups; however, in adapting to the unforeseen drop out of one of the control group participants, phase 2 of the experiment was repeated with that participant via video call. With the scenario task likewise acting as the prompt for the interview direction, I felt it most suitable to deploy an unstructured interview to allow the participant to expand in their own words their rationale for the task. The interview was thus conducted in a conversational manner, as is common with unstructured interviews, whereby I followed-up on points deemed insightful for answering the research questions (Bryman 2012, 471).

Figure 2 represents the research path, influenced by Robinson and Mandelson's (2012) qualitative experimental design. Experimental Condition 1 refers to the control group, and Condition 2 to the intervention group. The post-test interview

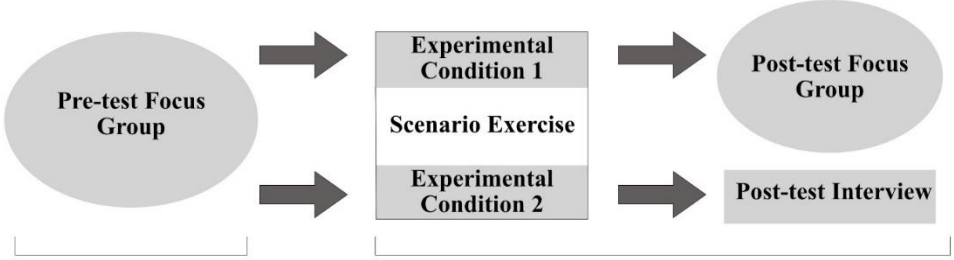


*Figure 2 Qualitative experiment pathway*

refers to the interview held with the one control group participant unable to make it to the post-test focus group.

### 3.2.3 The scenario exercise

Scenarios are descriptive future conditions centred on issues of uncertainty (Parson & Reynolds 2021; Amer et al. 2013). They allow for the exploration and structuring of existing knowledge, and the representation of which uncertainties are judged as decidedly important for participants (Parson & Reynolds 2021). The scenario was therefore an appropriate tool for the conveyance of perspectives for both the control and intervention group who entered a creative environment for investigation.

For the exercise, participants were handed a scenario which situated them as advisors on a task force for the UK government in year 2029. The year was chosen to situate the scenario in a tangible temporal context, whilst keeping the door open to speculation of how a UK government might look like in 5 years from now. By allowing for this creativity, I aimed to acknowledge and cater to the complexity of real-world decision making wherein pragmatic realism and imaginative speculation intertwine to direct action or motivation. SAI is likewise not currently at the point of sustainable nor substantial deployment, speculating on future context is thus inherent to deliberation of a not-yet deployed technology.

The participants' task was to formulate a position on whether to recommend or not recommend researching and/or implementing SAI. The task was made intentionally broad, with prompts only assisting to direct optional consideration. Participants were instructed to map their ideas onto paper provided, enabling the collection of data for the two different groups to be compared in the analysis stage. See appendix E for the task instructions.

### 3.2.4 Thematic analysis

Thematic analysis was selected as the method to analyse the data gathered. The method caters to the active role of the researcher who identifies themes and patterns not solely on their quantifiable manifestation within the data set, but on their prevalence in more tacit ways and whether they capture "something important in relation to the overall research question[s]" (Braun & Clarke 2006, 82). The process of coding and theme organising embraces the researcher's own positionality and, in

accordance with the critical realist approach, thereby allows the exploration of causal connections.

To analyse the data, both sessions were audio recorded, with the separated groups in phase two producing separate recordings. Phase two for the participant who was unable to attend the second session also produced a separate recording. Deepgram's transcription service was used to provide a mostly accurate transcription. Before submitting the audio files, I re-listened to ensure no sensitive data was present, clipping out any that remained. Mistakes in the transcription were corrected through again listening back to the audio recordings and changing what the programme misinterpreted. Whilst automatic transcription may only display the semantics of the data, my own observational notes taken during the sessions and the re-listening of the recording assisted with adding latent interpretation (Braun & Clarke 2006, 84).

Using NVivo, the data were then thematically coded. I adopted a deductive approach to the analysis, coding for the specific research questions and in search of certain themes, specifically related to the theoretical framework. These initial themes pertained to 1) counter-hegemonic thoughts and their relationship to vanguardism, 2) movement organising, 3) interconnections with capitalist transitionary tactics, including 'fixes.' With that said, given the lack of literature relating to the intersection of the climate movement and SAI, and the uniqueness of the examination for the first time the efficacy of the movement primer, I was open to unforeseen codes and themes emerging in the analysis stage.

In addition to the transcripts, my own field notes, and the paper on which the participants worked (mapping for the scenario exercise and any notes the intervention group made on their own copies of the movement primer), was analysed. Analysis was conducted deductively in the same six-stage approach along with the transcripts: data familiarisation, code generation, theme searching, theme reviewing, theme defining, and writing-up (Braun & Clarke 2006, 87).

## 3.3 Limitations

Ideally all participants would have been present for both phases of the study. The dropout of one participant constituted an unforeseen circumstance and the research design was altered to accommodate. It did however mean that the control group were unable to discuss their scenario task among one another in the same fashion

as the intervention group. I do not believe that this altered the findings in any meaningful way - all participants for the most part worked individually on their scenario and presented their own thoughts, meaning the experience of the control group participants was not drastically different to that of the intervention. A higher number of participants would have buffered the research from such circumstance (Bryman 2012, 517); unfortunately, sampling of participants who were available for two consecutive evenings in the one week of fieldwork proved harder than anticipated, despite the wide interaction with the sampling survey.

On validity, sufficient data was gathered for answering the research questions, and the variability between the participants as well as the experiment randomisation proves a benefit for internal validity. However, to improve external validity and robustness, the experiment could be reproduced with other participants in London's climate movement.

Finally, limitations of the focus groups pertain to the potential for more dominant participants directing the sessions (Robinson & Mandelson 2012; Bryman 2012, 517). Whilst some voices were more prevalent in the data than others, the focus groups were held in a safe and unjudgmental manner, with all participants engaging throughout.

## 3.4 Ethics

In line with Lund University's ethics guidelines (Lund University n.d.), participants were informed about the research before the commencing of both phases. Information about how data would be processed, stored, and used was likewise communicated. All interviewees were anonymised, save for their respective climate organisations. All other personal data, including name and contact details, were stored in an encrypted folder to be deleted once the thesis has concluded and been forwarded to participants. Participants were reimbursed for their time through the provisioning of food and beverages.

## 3.5 Positionality as researcher

I conducted this research from a critical position toward SAI. This position was developed through both my studies as a Human Ecology student, and my internship. As such, my position on SAI was already partially formulated prior to this research, informing the design and analysis itself. This reflects a subjective position on the

topic; however, all inquiry operates from a perspective, openness and honesty is thus the prerequisite for research to be credible.

Acknowledging my predisposition towards a critical stance, it is essential to highlight that this thesis aimed for rigor in its methodology and analysis. While my perspective undoubtedly influenced the direction and interpretation of findings, I endeavoured to maintain a balance by employing diverse sources, engaging with conflicting viewpoints, and critically assessing my own biases throughout. I did not reveal to participants that I co-authored the primer for this question was not asked; my own positionality, however, was conveyed to participants at the end of the study upon their request. On this point, I would also like to reiterate that my position and knowledge on the topic is fallible. Even if I believe a critical assessment of SAI is valuable, I welcome and encourage opposing angles. This likewise applies to the movement primer - it is not intended to dictate thought or action, rather build dialogue around SAI. The primer and any other radical education must thus encourage feedback from comrades and opposition so that it can be improved.

Finally, whilst I have spent most of my life in England and several years involved in climate activism, having now permanently moved to Sweden, I now operate as an outside researcher looking into London's climate movement. My aim is not therefore to judge and criticise the admirable work of a great many individuals who are seeking change in that context, but to offer comradery insight on how the movement could benefit from a more critical positionality.

# 4. Findings and discussion

In analysing my data, four themes were identified that prove relevant to the research questions. These will first be presented and analysed, before being discussed explicitly in relation to the research questions.

## 4.1 Findings

### 4.1.1 Toward systems change

Prevalent in the data set was an openness from participants towards large-scale social change in the interest of ecological sustainability. Whilst there was minor disagreement early in the first focus group regarding the scale and focus of the needed transformation, agreement was later reached on the general understanding that climate breakdown is a symptom of the capitalist system, therefore necessitating systemic change.

Diverging ideas of change were evident when participants were prompted on what could be done to build toward an ecologically sustainable society in the UK. One participant focused on the need to change individual action, stating that:

> I think behaviour is the way to go… People seem to assume they have to have a car, and don't want to use public transport (Participant 2).

When asked to reflect on what might guide such choices, the participant explained that "people get used to things, and then think they can't do without them" (Participant 2). This was countered by another participant, who suggested:

> We probably just need better solutions, like, better alternatives to cars so that you can get to places you want most of the time, as quick - or at least in a reasonable amount of time - as you can with a car. That's easy in London, but I think in the rest of the country it is hard (Participant 4).

The same participant later added:

> I think a lot of people feel like, 'oh, I do my recycling.' They've made certain shifts in their lifestyle and nothing's changed and they go, 'well, what's the point?' And they look at the big stage and go, 'well, what does it matter what I do?'… the average person needs to be rightfully frustrated at the people in power, and the people that are massive polluters (Participant 4).

Representing the first recognition that there are limits to individual agency under capitalism, this point was expanded:

> I think that also comes with, like, a change in economic structure. So, I think all of those things kind of stem from that, largely. A world that doesn't rely on endless consumption and growth, otherwise it's basically impossible (Participant 3).

Coalescing around this, Participant 1 suggested that for ecological transition to be sustainable in the long term and structural in nature, it "has to be popular" and it must be made "easy for people to make good decisions." A more systemic focus on change was subsequently carried through both phases by the participants, suggesting a clear angling toward system change that exists among members of London's climate movement.

Unpacking the position, participants reflected on the ontics of the climate crisis, conceptualising it in the following way:

> The climate crisis, I think, is just a manifestation of historical inequality, and I think that should be linked towards that and capitalism and our economic structure, and that can then be linked with every other social movement (Participant 3).

Similarly connecting to other social struggles, Participant 4 followed this track:

> At the birth of XR, I wasn't there to be honest. But it feels like that there's kind of an undercurrent of feeling initially that we can keep things broadly the same, but just make the right decisions, and we'd avoid this crisis. 'We just need politicians to make the right decisions and set up things in the right way.' But it feels, as the movement goes on and on, that there is this massive systemic collapse that is happening and will continue to happen. And the changing climate is a driver and a part of it. But like, there's so much more going on as well. So, you can't address climate change on its own. It's not a single topic anymore (Participant 4).

All participants, either audibly or through gesturing, agreed with this statement. With a consensus on the multifaceted nature of the crisis established, participants were prompted to consider the use of SAI, to which Participant 3 responded:

> We won't need it if there's radical climate action that should be happening. Like, we shouldn't be saying we should do this in the future when we can stop this crisis.

> What the hell are we doing here if politicians are thinking about those technologies and not ending fossil fuels? (Participant 3).

Again, both statements were affirmed by most participants, with one participant noting that, "we have the technology we need already, just not the political will" (Participant 4). This is representative of an initial concern expressed with regard to SAI among all participants, whereby a desire for system change was preferential to a technological 'fix.'

Tied to the engagement with radical ideas, participants shared the feeling that it is not enough to focus on esoteric scientific parameters, with one participant noting that it was important to commit education toward a goal that would respond to ecological catastrophe that has already befallen so many:

> I think… there's kind of a big focus on 'if we don't do something now, then there'll be doomsday for us later', rather than, 'people are suffering right now because of the actions that is happening'. And I think that it's a lot better to focus on that aspect, for a social justice point of view (Participant 3).

All participants recognised that such education must focus on the political-economic system driving climate breakdown, rebuking capital's false transitionary tactics, including greenwashing.

> I remember being at school, like, 20 years ago and learning about climate change. It doesn't seem unreasonable to conceptualise that. I think everyone has a basic understanding. I think the biggest problem is people kind of get persuaded by greenwashing (Participant 4).

Focusing on the need for education to be built around agency to elucidate change, participants theorised,

> Participant 3: I think people know the basic cause and effects of climate change… a big problem is people not thinking that they can really do anything about it.
>
> Participant 4: …there's probably a broader piece of education that could just focus on like, social movements that have worked. Because we haven't really seen anything work in the UK for quite a long time… we're kind of hoping that something can happen, but a lot of people feel disenfranchised and don't feel they have any power.

This was followed up with a humorous exchange about the UK schooling system not teaching how to support a counter-hegemonic movement:

> Participant 4: Doesn't really get taught how to collectively organise at school, unfortunately (laughter).
>
> Participant 3: Crazy that (laughter).

Despite being inferred as a joke, this exchange speaks to an underlying trend in the data, with participants identifying more educational work on movement building and radical organising to be important. Humour was regularly observed throughout the sessions, perhaps pertaining to the overwhelming nature of counter-hegemonic struggle, expressed by participants often qualifying and softening their statements. For example, during the scenario exercise, participants of the intervention group who were formulating an anti-SAI position, laughed at the notion of their task force advising the UK government to dismantle capitalism before considering SAI deployment:

> Participant 1: So, can we advocate for that in this?
>
> Participant 2: What, advocate for getting rid of capitalism? (laughter)
>
> Participant 1: The advisers to the UK government –
>
> Participant 2: Disband yourself and all of the fossil fuel industry (laughter).

Given the prevalence of the overarching theme ‘Toward system change’, it should be noted that the introduction of the movement primer did not seemingly alter participants’ understanding of the drivers of ecological breakdown, nor impart a new-found anti-capitalist critique. These results potentially demonstrate that London’s climate movement is already engaging with these thoughts. However, the primer did help build on participants’ existing understanding, contributing to a more critical understanding of how techno-fixes, and SAI in particular, can be weaponised by the capitalist system. These findings are presented in the following theme.

### 4.1.2 “Damage limitation” Vs. capitalist defence

Four of the five participants had heard of SAI prior to this research, with one participant having no familiarity with the technology. Those who had heard of SAI shared an understanding of the basics, expressing concerns about its use:

> I think I know a bit about it, that it's injecting aerosols like as happened when volcanoes erupted into the upper stratosphere with the aim of

> shielding, screening out some of the sun rays… my feeling is it doesn't hit the basic cause of climate change, which is climate emissions. And even if it means we get less sun rays… so less warming because of that, if those aerosol particles go away, and we haven't bothered doing anything about carbon or not enough, then there'll be a massive overshoot (Participant 2).
>
> The things I have heard is that it's a very late-stage solution and last-minute solution to the climate crisis that should kind of be avoided at all costs, for reasons that it's very dangerous (Participant 3).

These findings slightly contradict the results from the participant sampling survey, whereby just over 40 per cent of responders (30 out of 71[1]) indicated that they had no knowledge of SAI prior to the survey. It is possible that participants with knowledge of SAI were more inclined to participate in the research owing to an interest in the topic. The findings suggest, however, a baseline knowledge of SAI within London's climate movement. This correlates with the increasing research and prevalence in climate discourse.

Most relevant for the research questions was in the divergence between the control and intervention group, the most prevalent of these differences relating to the use of SAI as an option for damage limitation as reasoned by participants of the control group. Conversely, participants of the intervention group drew heavy inspiration from the movement primer and were more critical of its capacity as protector of capitalist interest and functionality.

This developed first with a consideration from participants to the political nature of technology, and whether SAI could feasibly be useful in a different political context. Such reflections formed a shared consensus, whereby the use of SAI in the current historical context would necessarily be political and reflective of the contemporary hegemonic political position. This is seen in the following reflections, first from an intervention group participant who, drawing from the intervention material, stated:

> we can't do this in a safe way under capitalism. Therefore, we shouldn't do it because what we have is capitalism. The other option would be to not have capitalism as - that's possibly out of scope for this - but, like, address the root cause of why this would necessarily be bad which is capitalism.

[1] Note: while there were 73 responses to the survey, 71 responses were recorded for this question.

> But just to say, I don't think this is necessarily an absolute argument against any research under any circumstance (Participant 1).

And likewise, from a control group participant who reflected:

> I guess in my mind, the technology itself is not political. Like, theoretically, this technology would be useful in other scenarios… Say if you did have some solar event where this was necessary, it would be useful to have this technology. But it certainly is going to be politicised (Participant 4).

Connected to such deliberations marks a major difference between the control and intervention group, with the latter focusing on its capacity to act in defence of capital:

> My feeling is if people think it can be used, they will just say, 'why should we bother doing anything? Why should we bother cutting our climate emissions?' Because this will be this magic technology (Participant 2).
>
> I don't really think we should be researching it, and we need massive structural and economic change before we start researching it or consider applying it in a socially just way (Participant 3).
>
> We're saying stop using fossil fuels, and they say well 'no we're going to carry on using fossil fuels.' And if it starts effecting their businesses etcetera, they'll try other fixes that they think might let them carry on. And if people say, 'oh, but,' they'll say, 'well, we're gonna do it anyway.' They'll lie about it then… they'll lie about this (Participant 2).

The statements were reaffirmed and written out in the scenario exercise, wherein all participants of the intervention group developed a position for their respective task force to recommend *not* researching or deploying SAI. Notably, Participant 2 built upon their critical understanding of carbon capture and storage (CCS), comparing its use as a defensive spatiotemporal fix to the capacity of SAI to act in a similar fashion:

> There could be companies that use it as an excuse... Like they use carbon capture and storage as an excuse to say, 'oh, we'll carry on emitting, and then we can do this' (Participant 2).

There was a clear change likewise with the perception of SAI for one of the intervention participants before and after the introduction of the primer. Notably, before the intervention, Participant 1 reasoned:

> we might be in a position where not doing it is worse… if it turns out that this technique, geoengineering, any of the techniques, do have a good chance of reducing the risk of the ice packs melting, which we for sure know that they basically already are, then that should be explored.

The participant changed their position after the introduction of the primer, later stating:

> It seems like we have some basis on which to say that if we research this, we make it more likely that it will be deployed. And if it is deployed, it could be very bad. And currently we don't have any governance structures, which could mitigate the badness, because of… the system that we have, which is a capitalist one. So, before we consider researching or deploying geoengineering, we should have a different economic system (Participant 1).

Those that received the primer concluded that system change must take place prior to any consideration of SAI, owing to the inability of capitalism to deploy SAI in line with principles of justice and democracy.

The control group on the other hand, whilst noting the potential for SAI to let "polluters off the hook for climate destruction" and in its capacity to give "them a new greenwashing tool" (Participant 5), primarily considered SAI as a tool to limit further ecological destruction:

> There are plenty of risks, but we're looking at, like, damage limitation rather than… the solution to the climate crisis (Participant 5).

In weighing up its use, the participant recommended conducting,

> some sort of cost-benefit analysis… that looks at each sector of the economy, and preferably takes a sort of human focused analysis as well (Participant 5).

Participant 4 concurred:

> It's definitely worth considering… it does seem to have a lot of advantages… I don't think any of these geoengineering products are gonna be the ideal solution. But there's a lot of advantages to it.
>
> I guess because it's quite a cheap solution, and particularly if we're looking at, like, getting above, like, 2 degrees or something. I think it's probably fairly easy to make, an economic case for it, which feels a bit sad to me. But

these things are important to get things done. You could improve the world economy by deploying this (Participant 4).

This was followed up by recommendations for more research and a suggestion of a governance model (see section 4.1.3).

There is then a clear difference between the intervention and control group, with the former adopting a more critical position toward SAI, going beyond the content of the primer, and linking SAI with the mitigation delay concerns they have for CCS. Evidently then, the introduction of the educational movement primer influenced participant's perceptions, connecting harboured critiques of capitalism to SAI. This suggests several findings: firstly, education of this kind is received and absorbed, connecting with some of the world building that is happening within London's climate movement. Secondly, without such SAI-specific education, it is more likely that the technology will be seen simply as a damage limitation strategy, risking paternalistic deployment if conceived in such a manner without critical deliberation.

### 4.1.3 Deliberation and decision making

Crucial for all participants was the need for SAI to be deliberated in a publicly overseen way:

> Participant 1: But if it is deployed, we need a system of governance, which has to be binding.
>
> Participant 3: Which would have to be very democratically decided, through citizens' assemblies and stuff like that.

The intervention group were sceptical of the realities of such deliberation in the contemporary context. Drawing from the primer, doubt was raised about the ways in which a universally binding governance structure could be developed to oversee and manage deployment, should it get to that point:

> Worldwide, we won't be able to manage it properly. Countries that want to back out will, as Trump did, as it says over the Paris agreement (Participant 2).
>
> I think- we can't really decide on it in a very democratic process under our current system (Participant 3).

For a technology that will necessarily affect everyone on the planet, serious concerns for sovereignty were expressed, as was concern for the precedent of existing international governance structures:

> Companies are getting so huge. They could just say they're doing it... it's a global problem. We need a global government, and we don't have one, and it's very unlikely that we would have one (Participant 2).

Members of the intervention group likewise considered issues with technocratic actors overseeing research and deployment:

> We can't have a 'scientist making all the decisions model' because that, I think, leads to extreme injustice from people who are just left behind… Scientists aren't necessarily benevolent. A lot of them are, but a lot of them are not (Participant 2).

This point was expanded further into a consideration of the boundary work of experts and the personal agenda of the individual considered:

> knowing how governments operate, if they want to have a goal to determine and elaborate details of its deployment, then they'll just find some other experts… that will want to work towards deploying it (Participant 2).

Technocratic oversight was similarly considered by the control group; however, Participant 4 felt research and deliberation would best be left to scientific bodies:

> I think research wise, it has to be in the hands of health organizations, I think… it needs to be as far away from private capital as possible… I don't know how you get money completely away from private capital, especially in this sort of space, you always have donors and whatnot. But ideally, in a WHO or IPCC sort of sphere… And to be honest, I probably want this the same group of yeah, probably the same group of people making the decision to deploy.
>
> The ideal is that the IPCC and the kind of the scientists who are connected with this just have more power and more funding, the ability to handle these things because I don't think there's any state or private company that I would trust (Participant 4).

These thoughts speak to the 'listen to the science' demands that have been prominent in the UK climate movement, and potentially overlook the ontological immateriality of scientific bodies that operate from a particular worldview and are prone to Promethean conceptions of technological innovation. The point is further

supported by remarks from the same participant who, when deliberating reductionism versus technological innovation, stated,

> some people just think we can innovate our way out of this… we just need more research, and we'll just get the right thing, which has arguments in some case. Like, if you managed to get hydrogen power working, fusion power… if we manage to scale, because we do it in a tiny way now, then that would change energy consumption in a huge way (Participant 4).

The apparent political neutralism of technology thus giving a green light to technological advancement to deliver us from ecological ruin, in turn ignoring the intrinsic social and political nature of said technologies.

The other member of the control group illustrated a proposed governance framework during their scenario task (Figure 3).

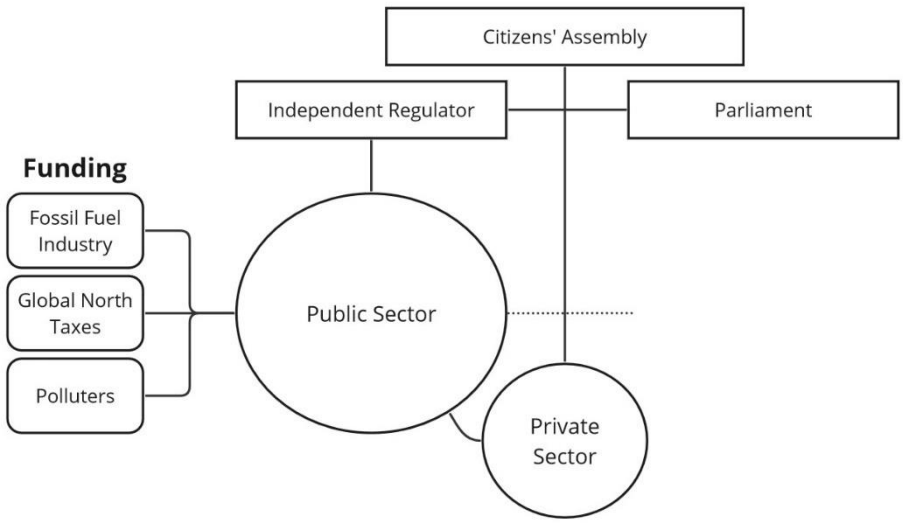


*Figure 3 Digital rendition of Participant 5's governance model*

This framework, built around the premise of a publicly funded research programme, featured independent regulators "who are appointed by citizens assembly and parliament." The participant was inspired by the US' Apollo program, explaining that a successful governance model "was the one that obviously got the US to the moon, right, it's like a publicly funded and designed project which brought in the private sector when it was needed" (Participant 5). Interestingly, a publicly overseen research programme has been recommended by the US National Academies of Sciences, Engineering, and Medicine (NASEM). This will be considered in the discussion.

Finally, a prominent code to emerge within this theme of decision making was that of citizens' assemblies (CAs), with some participants suggesting these might

be a forum in which to deliberate SAI. This can be seen in Participant 5's governance framework, and the quote at the top of this theme section. CAs likewise featured as a suggestion to build toward a different economic system:

> One way we could move towards that is by, supporting efforts of democratic engagement or direct democracy, such as having a citizens' assembly, which has the power to kind of implement or move on its findings or its agreements (Participant 1).

Given the prevalence of this deliberation method within the UK climate movement, it was unsurprising to see its emergence in the research. When asked whether participants could envision the UK government obliging the conclusions of a CA if the conclusions would require the dismantling of the capitalist state itself, the participant responded,

> No, it wouldn't be possible for it to be given that power, or they could say they would give it unlimited power until it comes up with an outcome like that (Participant 1).

Rather, where the participants saw the power of the CAs was not in their contemporary capacity to enact radical change, but in their deliberative purpose:

> I was at one the other day, when XR did their week against insurance companies, basically. And even… if none of the demands are met, I don't see it as so black and white. Let's say they took nothing seriously, even then you would have had people getting together, talking about the issues that they have and trying to come to some sort of solution, and that's more than we're doing at the moment. We just have… complete blockage in our political systems where no one trusts the politicians to do anything, and no one has the vocabulary or the tools to start to work it out themselves... Even if they're not taken seriously, people start demanding more because they see that they can (Participant 5).
>
> When lots of different people come together to decide on something and have conversations about it, much more radical approaches become a lot more acceptable… people are more willing to do more radical approaches then (Participant 3).

For the participants in the study, the CAs therefore offer a place for the movement to deliberate not just SAI, but other more radical ideas. Recognising that in the current political landscape, these assemblies alone will not enact required

changes; however, they can dialectically assist with organising and facilitate counter-hegemonic movement building. Or, as aptly put by a participant, “consciousness raising, is a way you could see it” (Participant 1). There could thus be a synergistic relationship between primer based radical education and CAs, the contents of the former being discussed and debated in the latter.

### 4.1.4 Contrasting with the Palestine movement

The final theme to explore is the comparison participants made between the climate and the Palestine movement. In contemplating why the climate movement has stalled in its outreach, the participants reflected on the large mobilisation in support of Palestine:

> I think you can see a difference when you look at young people interacting with the Palestine movement and how active they are in that. I think part of the reason why that hasn't happened as much with the climate movement is… you can't see it. It's like a thing that you can't really conceptualise… there's a more blurry cause and effect (Participant 3).

Building on this, another participant compared the way in which climate change is presented:

> ‘This was 20% more likely because of something we did’. It doesn't hit the same as these people did this thing. It killed them directly, with bullets (Participant 4).

This speaks to the difference in reaction to the genocide in Gaza, where oppression is easier to comprehend for the participants compared to the slow violence of imperial ecological devastation:

> I think with the climate movement, people aren't seeing videos of dead babies on their timeline, like, every single day. I think that's a big impact of it. For a human aspect, I personally don't even see a lot of the effects of the climate crisis right now in terms of human suffering (Participant 3).

The genocide in Palestine is imbricated with European colonialism and extractivism; whilst the visibility and horror of this violence has illuminated the brutality in a manner more digestible to many, it reifies the need to connect these struggles toward the broader anti-capitalist and anti-imperial fight. Although this thesis specifically focuses on SAI, it bears remembering that such analysis works as a nexus through which to examine the narratives around anti-capitalist struggle,

and how to work toward this end. Further, this final theme has helped to underscore how technologies are always imbricated with the political questions of our time, themselves political artifacts to be analysed relationally to the powers shaping their development.

## 4.2 Discussion

With the themes presented and analysed, I will now synthesise the findings and discuss each research question in turn. Starting firstly with addressing the perception of SAI among members of London's climate movement.

### 4.2.1 Problematic perceptions

SAI is on the radar of London's climate movement, with a significant portion of survey respondents and research participants demonstrating an understanding of the basic premise. While this awareness is poised to grow alongside SAI's increasing prominence in climate discourse (Möller 2023, 27; Millman 2022), the movement currently lacks a thorough, critical examination of the technology and its underlying structural dynamics. Taking the findings from the control group and that of the intervention group (prior to the experiment)[2], the prevailing understanding of SAI revolves around its perceived cost-effectiveness as a potential strategy to mitigate the most severe impacts of the climate crisis. Through this lens it is viewed as a pragmatic approach, representing a form of 'damage limitation,' preferable to inaction.

The control group was open to current international governance structures acting as functional overseers of SAI research and deployment. These perceptions were followed through with tentative support for a last resort deployment from the control group, to be overseen by the likes of the IPCC or a publicly funded research programme. The findings mimic those of a 2019 study in which over half of the polled negotiators and scientists working for the IPCC and UNFCCC supported deployment of solar geoengineering ahead of a looming ecologically catastrophic event (Dannenberg & Zitzelsberger 2019; Malm 2022 32).

I will discuss both points in turn. Foremost, support for a last-ditch deployment is an understandable reaction, especially in the context of the nightmarish

[2] Note: for clarity, I refer here to all data from the control group, and the intervention group's data from phase one of the study, prior to exposure of the intervention material.

ecological crises we have already bore witness to. Implied here is the need for further research so that in the event of whatever looming catastrophe deemed great enough to warrant deployment, it can be initiated. This, however, brings its own risks: what is initially hypothetical research subsequently socially manufactures consent for techno-fixes as a viable response to the climate crisis. This problem is referred to as the "slippery slope," whereby research builds to experimentation, increasing the potential for eventual deployment through normalisation and institutionalisation (Oldham 2014). A similarity is shared with the previously explored future-making capacities of IPCC's IAMs, and in the propagation of Promethean technologies proposed as fixes to capitalist contradictions. In being perceived as a failsafe to the underproduction crisis, SAI thereby takes the form of a spatiotemporal fix. Problematically then, what would possibly compel the capitalist state to mitigate carbon emissions if there exists a lever with the potential to reconfigure the crumbling atmospheric conditions? Worse yet, in the event of deployment, what would enforce decarbonisation upon the temporary relieving of boiling temperatures?

Both research and deployment of technology must thus be considered political and reflective of the system within which it is developed. Argued by by Ajl, "it is those claiming that technologies are socially innocent who have the burden of proof, for theories of imperialism and environmentally unequal exchange show that they are not socially innocent" (2021, 55). I therefore turn to addressing the second perception: that a publicly funded body or specifically the IPCC ought to oversee research and development of the technology.

A publicly funded body, not too dissimilar to that envisioned by Participant 5 in the scenario exercise, has been proposed by NASEM. Though their report recognises the dangers of advancing unilateral research before broad public participation and global governance structures are in place, the report recommends the establishment of a US national solar geoengineering research programme (NASEM 2021). These recommendations are explicit, developed without public participation and in the absence of sound governance structures, thereby undermining its own warnings in the processes (Stephens et al. 2021). It also fails to recommend that any research programme be "conditional on the prior development of international governance mechanisms and substantive participation," pushing participatory engagement and governance challenges to be

dealt with after research itself (Ibid., 158). The report and its suggested programme thus pre-empt public participation, shaping research a priori. Consent is therefore assumed before global consultation and deliberation has even begun. Thus, even a publicly overseen and funded research body would speak on behalf of the many given the global repercussions of SAI deployment.

On the point of deliberation, it is up to SAI proponents to demonstrate how such debate will be held, in which forum, how all voices will be equally represented, all knowledge respected, and to offer concrete assurances for mitigating the "slippery slope" and abatement concerns related to the propagation of what this thesis contends as a spatiotemporal fix. True participation and deliberation necessitate an interrogation of the imperial world order, the colonisation of the stratosphere, and the negotiation of reparations. SAI therefore requires a *lack* of genuine participation for it to be of use for the capitalist core, potentially giving rise to faux box-ticking consultation. Injustice thus lies in SAI's role as an imperial technofix originating from the global North, sustaining capitalist interests, delaying mitigation efforts, and silencing alternative options (Surprise 2020) – all under the guise of supposed humanitarianism.

Taking this point further, argued by Whyte (2018a), expecting Indigenous consent to SAI is similarly flawed due to limited representation within international governance structure and because SAI itself constitutes an imperial intervention. Indigenous peoples did not consent to the colonial power relations of the world that have made necessary consideration of SAI. In seeking consent for geoengineered solutions, one therefore risks undermining "anti-colonial and decolonial reforms that Indigenous peoples have been calling on nations and corporations to do for years." (Whyte 2018a, 303). A similar point is made by Ajl who writes, "there is no hope that Palestinians – or Yemenis – will receive and control climate debt reparations unless they have de facto and de jure national sovereignty, the political shells within which thinking about the future can occur" (Ajl 2021, 149). This is not to say consultation and deliberation should not be held; rather, deliberation ought to depart first with calls for land repatriation, and the current asymmetrical international institutions overhauled.

In paternalistically marching ahead with research and leaving governance conveniently to after the fact, questions pertaining to the global winners and losers in an SAI future are similarly circumvented (Szerszynski et al. 2013, 2812). If the

US was to fund the research, are we to assume they would accept a deployment that would negatively impact their economy? As for the IPCC as a governing actor for deployment, the perception of such a body being up to the task has likewise been shared by an SAI proponent who speaks of the credibility the institution already possesses (Rabitz 2019, 513). This suggestion is ridiculed by Malm (2023a), who points out that the "inclination to comply with the IPCC would have long ago obviated a deteriorating climate crisis and thereby any considerations of geoengineering" (2023a, 10).

The baseline perception of SAI within London's climate movement could represent a problematic assumption of its imperatives, and potentially overlook its defensive spatiotemporal fix properties and interrelated governance shortcomings. The following section will in turn address the influence of the primer, and the relationship with vanguardism. The effects on perception following the introduction of the primer perhaps speak to the potential for systemic change to be materialised, and liberation achieved without legitimate consideration of a deeply flawed and dangerous technology.

### 4.2.2 Effect of the primer

The introduction of the movement primer significantly influenced the perception of SAI for the intervention group. This is evidenced by the change in perception for Participant 1, before and after their exposure to the primer, and in the critical position adopted by the intervention group when contrasted with the perceptions of those in the control. It is worth emphasising here that the primer's impact on perception was not assumed, its effect therefore supports several key points. Foremost, the critical angle of the primer connects with some of the world-building of London's climate movement members, potentially suggesting an emerging trend where political consciousness is on the rise. It is important to note the relatively small sample size of the research, indicating the need for further investigation into this potential shift. That the intervention group was able to connect an analysis of SAI as a defensive mechanism for capital with their own understanding of CCS acting in a similar way does, however, suggest a pre-existing material and political understanding of technology and 'quick-fixes.' Likewise, in conceptualising the climate crisis as inherently political in character, and in explicitly naming capitalism

as driver of ecological breakdown, participants demonstrated that members of the movement are likely directly framing the root cause of the crisis.

The control group, despite displaying an understanding of the systemic nature of the climate crisis, ultimately channelled a more apolitical conception of SAI. This buttresses the necessity for political education that resonates with existing worldviews already present within the movement. In this context, the primer's success in disseminating a critical analysis of SAI among the participants was evident, demonstrating the capacity of the conceptualised vanguard layer in fostering revolutionary and counter-hegemonic consciousness.

Drawing from the work of Norgaard (2011), climate inertia speaks to denialism that is rife in core capitalist societies. While the world burns, the majority continue as though it were not the case. This is not through a failure to comprehend the realities of the crisis, rather a suppression of this actuality, termed implicatory denial (2011, 11)[3]. Central to this argumentation is the critique of the information deficit model: more information will not combat denialism because most people have already reached saturation with climate science. However, the findings of this thesis suggest that even if the realities of the crisis are well understood (one would expect as much from those active in the climate movement), more information specifically related to quick-fixes and their intrinsic politics is worthwhile.

It is ultimately the aim that levels of consciousness developed through the dialectic of radical political education and action (i.e. praxis) will reach a point wherein the climate movement is able to respond in a principled and socially just manner to whichever new phenomena or transitionary tactic capital rolls out. The difference in perception between the control and intervention group therefore demonstrates we have not yet arrived, and the vanguard layer remains tasked with building broader support toward an anti-capitalist end.

In recognising the need for radical deliberation on systemic counter-hegemonic movement building, the participants highlighted their experience with CAs. The participants' views on CA's diverges from the existing literature on the assemblies that highlights a subduing of ulterior ideas through a prioritisation of consensus (Machin 2023). With broader political consciousness, it is possible that such forums allow instead for the deliberation of a plethora of ideas that subvert those offered

[3] Note: Norgaard (2011) extends Cohen's (2001) original conception of denial typologies and applies them to the climate crisis.

by the status quo, creating a space for the debate of dialectical analyses. Thus, even if imperfect, the potential for CAs to transform into spaces of radical deliberation is promising for a movement that is possibly becoming more revolutionarily conscious. Such forums could likewise be a place to disseminate and reach those that have not yet engaged with this thinking; this is requisite however on the continued engagement with radical counter-hegemonic ideas that challenge capitalist common sense. Rather than focusing solely on their limitations – I would still contend that relying on the UK government ceding power toward counter-hegemonic decisions that might emerge from CAs is a dead-end - the CAs should instead be encouraged as a forum for radical discussion and political analyses.

I now turn to the final consideration: the capacity to effectuate systemic change.

### 4.2.3 United liberation

The inception of this thesis stemmed from worry that a depoliticised perception of SAI may garner uncritical approval within the UK's climate movement. Representing justification for more education around SAI, the findings demonstrate that this remains a valid concern. That this technology will alter our shared atmosphere calls for collective engagement, and the dangers are such that honest and just deliberation must be had before any further research into the technology. More than that though, the efficacy of the primer was in its scope, whereby SAI was subsequently understood as problematic because of the power that will likely deploy it: capital. In building scaled capital analyses into the climate movement, a nuanced understanding of contradictions can be developed.

Turning to the final research inquiry, that of systems change, brings us back to the relationship between radical education and counter-hegemonic movement. Lenin stated that, "without a revolutionary theory there can be no revolutionary movement" (2014 [1973], 21) - the core impetus for the vanguard layer and the theoretical framework that has guided much of this thesis. Equally important then is the practice that is shaped by such theory, the recurrent relationship between the two allowing for the emergence of praxis. Revolutionary action should therefore not be, "reduced to either verbalism or activism," nor can it "designate its leaders as its thinkers and the oppressed as mere doers" (Freire 1970, 125-6). It must operate in dialogue built upon internationalist solidarity and alliance with other struggles against oppression. Theory alone is not enough, and neither is siloing one

struggle from another in the face of a shared and organised enemy. An individual round of demonstration is insufficient for system change; however, with each new cycle there is experienced gained. This can create a conditioned movement, and the allying of many counter-hegemonic struggles under a common banner of anti-imperialism and anti-capitalism stands a greater chance of liberation from capital and ecological disaster (Heron & Dean 2022).

On one hand, there have been promising signs of this in practice. Here, I refer to the solidarity demonstrated by much of the UK's climate movement with Palestine, marking an historic juncture whereby - despite early delays - widespread support among climate organisations *now* seems the norm (Climate Justice Coalition n.d.). Participants acknowledged this solidarity, commenting on the large mobilisation. Given the interconnection between settler colonialism and environmental destruction, support for Palestinian liberation is essential. As addressed by Whyte, "settler colonialism commits environmental injustice through the violent disruption of human relationships to the environment." (2018b, 125). Land liberation is therefore a pathway toward environmental restoration, the former tightly bound with the latter, and must necessarily be held as requisite in any transition toward environmental justice (Ajl 2021, 159).

The powers that support Israel's oppression are likewise the same powers that block environmental justice, proliferating instead further carbon extraction and/or green capital accumulation. Violence operationalised against Palestinian decolonisation struggle should thus represent a brutal reminder to us in the climate movement the lengths to which imperial capitalist powers will go to protect their interest, and subsequently the scale of the challenge ahead. It is no coincidence that Israel's Iron Dome and SAI share commonality in their repression of symptoms for it is capital behind both symptomatic plugs, unable to resolve its own causal contradictions (Malm 2022, 2). Whilst participants noted that they felt a difference in terms of the observable brutality of bombs versus the slower violence of the climate crisis, recognising their interrelationship is integral to the success of the system change the participants' and London's climate movement potentially desires.

With that said, the initial delay in support for Palestine from the UK's climate movement, and the continued silence of other organisations in Europe, Ende Gelände for example (Heron 2024), reifies that this true dialogical relationship is

yet to emerge, and the struggle against imperialism and capitalism remains fractured and spontaneous in its organising. It is therefore necessary that work continues building and disseminating dialectical analyses of capitalism, and on deliberate organising toward counter-hegemonic ends. There remains an issue of scale, wherein the capacity of the climate movement to internationally link with other struggles is hampering any counter-hegemonic momentum. This point was made by the participants who lamented the lack of organisational training they have received. This thesis and the movement primer is thus one small cog in the work of the vanguard layer, the aim of which is to build a global coalition of revolutionary dialogue and uncompromising liberation.

# 5. Conclusion

I aimed to achieve three primary objectives in this thesis: firstly, to investigate the current perceptions of SAI among members of London's climate movement; secondly, to evaluate the effectiveness of political educational material in fostering a critical perspective, conceptualising this according to the Leninist notion of the vanguard layer; and thirdly, to explore how the vanguard layer might contribute to the pursuit of counter-hegemonic objectives through the transformation of London's climate movement into a radical force. In examining the perceptions of SAI among members of London's climate movement, this thesis contributes to filling a literature gap in terms of public consultation and deliberation of the technology. Further, in assessing the application of the vanguard layer, the thesis aims to build toward radical movement-building strategies, an ever-pressing need owing to the fast-depleting temporal scale left for transformative action. Limitations of the study pertain to the single qualitative experiment; to validate these findings further, the experiment could be repeated with other members of London's climate movement.

The inception of this thesis stemmed from worry that a depoliticised perception of SAI may garner uncritical approval among members of London's climate movement. This remains a valid concern. Whilst the findings demonstrate that some in the movement are aware of the basic functionality of SAI, and support for systems change is present, the pre-intervention and control group perceptions speak to a hangover of the climate movement's apolitical era. Evidenced through creeping technological neutralism and an optimistic trust in liberal governance structures, the findings justify a need for the dissemination of more critical education on SAI and perhaps techno-optimist ideas more broadly.

Promisingly, the primer was effective in its scope, whereby SAI was subsequently understood by the intervention groups as particularly problematic because of its synergy with the systemic drivers of our ecological crises: capitalism and imperialism. In building scaled capital analyses into the climate movement, a nuanced understanding of contradictions can be developed. The findings therefore demonstrate the benefits of critical education, supporting the efficacy of the Leninist vanguard strategy in weaving dialectical analyses into our movements. However, theorising alone is insufficient, with participants noting the lack of

organisational practice. On this front, CAs may be a place to turn. Whilst not revolutionary in of themselves, the sympathy they enjoy among members of the climate movement infers they may be here to stay. They could instead be transformed into forums to allow for dialectical debate and perhaps even offer places through which to recruit members toward a more revolutionary oriented body. More research could be directed for the exploration of CAs in this capacity.

SAI currently exists in the realms of computer modelling and early-stage field testing. There it must remain at least until deliberation has been had, and system change commenced. Without such, SAI will buttress capitalism and reproduce imperial power relations, unleashing catastrophic side effects. This is not advocacy for SAI in a different socioeconomic context but a call to revolutionary arms to be trained against capital. Capitalism must remain front-and-centre in the scope of radical left climate praxis. We cannot solve the contradictions of capitalism under capitalism for these are inherent to the system itself, transcending the contradictions thus eventually requires an altogether different socioeconomic system. SAI is thus another hindrance to the realisation of an eco-socialist future, the deployment of which must be resisted whilst it is still in the theoretical stages. There is much work to be done, but the efficacy of the primer in connecting with the climate movement demonstrates hope for liberation under a blue sky.

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# Appendices

## Appendix A Survey questions

**Solar Geoengineering and Climate Movements**

Solar geoengineering is growing in academic and political popularity. Inherent to its operation is its global effect, it is therefore vital that the climate movement engage with the debate to form a strategic position.

This survey is part of a Master's thesis investigating the climate movement's current positionality in regard to solar geoengineering, specifically stratospheric aerosol injection. It constitutes part of a broader analysis on climate movement strategies and theories of change as we in the movement strive toward a just, green transition. Engagement from those active in the climate movement is hugely appreciated.

This information will only be reported in aggregate, and individual responses kept confidential.

**Gender Identity (select all that apply):**

- Female
- Male
- Transgender
- Non-binary
- Prefer not to respond

**Ethnicity**

- Asian
- Arab
- Black
- White
- Multiple
- Prefer not to respond

**Age**

- 16-20
- 21-25
- 26-35
- 36-45

- 46-55
- 56-64
- 65+
- Prefer not to respond

**Employment**

- Part time
- Full time
- Unemployed
- Student
- Retired
- Prefer not to respond

**Which climate organisation(s) are you active with?**

---

**Had you heard about stratospheric aerosol injection before this survey?**

- Yes
- No
- Maybe, not sure

**Do you understand how solar geoengineering, specifically stratospheric aerosol injection (SAI), works?**

- Yes, I am very familiar
- I understand the basics
- I have heard of it, but I am not aware of its operation
- No

**To what degree do you agree with the following statement: "to combat rising temperatures, solar geoengineering might be required"**

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly Disagree
- Not sure

**To what degree do you agree with the following statement: "climate scientists are best positioned to solve the climate crisis"**

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree
- Not sure

**To what extent do you agree with the following statement: "solving the crisis requires further technological advancement"**

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree
- Not sure

**Please briefly explain your previous answer**

---

**Please select if you would be willing to take part in two focus group / simulation exercises on week starting March 18th in London.**

- Yes
- No

If yes, please leave your name and contact information below. Alternatively, reach out: **(redacted)**

# Appendix B Consent form

## **Consent to participate in a Thesis at the Faculty of Social Sciences**

I agree to participate in James Mace-Moore's Solar Geoengineering Master's thesis.

This research forms part of a Master's degree thesis, produced at Lund University for the Human Ecology MSc programme. Your first name and email address will be collected, to be used to forward to you the thesis upon completion. You will be anonymised, and referred to using a pseudonym.

**Information on the processing of personal data**

The following personal data will be processed:

- First name
- Email
- Affiliated climate organisation

Personal data will be processed in the following ways:

- Stored in an encrypted folder, and deleted June 2024.

We do not share your personal data with third parties.

Lund University, Box 117, 221 00 Lund, Sweden, with organisation number 202100-3211 is the controller. You can find Lund University's privacy policy at www.lu.se/integritet

You have the right to receive information about the personal data we process about you. You also have the right to have inaccurate personal data about you corrected. If you have a complaint about our processing of your personal data, you can contact our Data Protection Officer at dataskyddsombud@lu.se. You also have the right to lodge a complaint with the supervisory authority (the Data Protection Authority, IMY) if you believe that we are processing your personal data incorrectly.

I agree to participate in James Mace-Moore's Solar Geoengineering Thesis:

| | |
|---|---|
| Location | Signature |
| Date | Name clarification |

# Appendix C SAI basic overview

## Background on SAI

*The following bodies of text have been directly copied and pasted from Wikipedia (12/03/2024), and can be accessed through the following link: https://en.wikipedia.org/wiki/Stratospheric_aerosol_injection*

**Stratospheric aerosol injection** is a proposed method of solar geoengineering (or solar radiation modification) to reduce global warming. This would introduce

aerosols into the stratosphere to create a cooling effect via global dimming and increased albedo, which occurs naturally from volcanic winter. It appears that stratospheric aerosol injection, at a moderate intensity, could counter most changes to temperature and precipitation, take effect rapidly, have low direct implementation costs, and be reversible in its direct climatic effects. The Intergovernmental Panel on Climate Change concludes that it "is the most-researched [solar geoengineering] method, with *high agreement* that it could limit warming to below 1.5 °C (2.7 °F)." However, like other solar geoengineering approaches, stratospheric aerosol injection would do so imperfectly and other effects are possible, particularly if used in a suboptimal manner.

**Advantages of the technique**

The advantages of this approach in comparison to other possible means of solar geoengineering are:

- **Mimics a natural process**: Stratospheric sulfur aerosols are created by existing natural processes (especially volcanoes), whose impacts have been studied via observations. This contrasts with other, more speculative solar geoengineering techniques which do not have natural analogs (e.g., space sunshade).
- **Technological feasibility**: In contrast to other proposed solar geoengineering techniques, such as marine cloud brightening, much of the required technology is pre-existing: chemical manufacturing, artillery shells, high-altitude aircraft, weather balloons, etc. Unsolved technical challenges include methods to deliver the material in controlled diameter with good scattering properties.
- **Scalability**: Some solar geoengineering techniques, such as cool roofs and ice protection, can only provide a limited intervention in the climate due to insufficient scale—one cannot reduce the temperature by more than a certain amount with each technique. Research has suggested that this technique may have a high radiative 'forcing potential', yet can be finely tuned according to how much cooling is needed.
- **Speed**: A common argument is that stratospheric aerosol injection can take place quickly, and would be able to buy time for carbon sequestration

projects such as carbon dioxide air capture to be implemented and start acting over decades and centuries.

**Uncertainties**

It is uncertain how effective any solar geoengineering technique would be, due to the difficulties modeling their impacts and the complex nature of the global climate system. Certain efficacy issues are specific to stratospheric aerosols.

- **Lifespan of aerosols**: Tropospheric sulfur aerosols are short-lived. Delivery of particles into the lower stratosphere in the arctic will typically ensure that they remain aloft only for a few weeks or months, as air in this region is predominantly descending. To ensure endurance, higher-altitude delivery is needed, ensuring a typical endurance of several years by enabling injection into the rising leg of the Brewer-Dobson circulation above the tropical tropopause. Further, sizing of particles is crucial to their endurance.
- **Strength of cooling**: The magnitude of the effect of forcing from aerosols by decreasing insolation received at the surface is not completely certain, as its scientific modelling involves complex calculations due to different confounding factors and parameters such as optical properties, spatial and temporal distribution of emission or injection, albedo, geography, loading, rate of transport of sulfate, global burden, atmospheric chemistry, mixing and reactions with other compounds and aerosols, particle size, relative humidity, and clouds. Along with others, aerosol size distribution and hygroscopicity have particularly high uncertainty due to being closely related to sulfate aerosol interactions with other aerosols which affects the amount of radiation reflected. As of 2021, state-of-the-art CMIP6 models estimate that total cooling from the currently present aerosols is between 0.1 °C (0.18 °F) to 0.7 °C (1.3 °F); the IPCC Sixth Assessment Report uses the best estimate of 0.5 °C (0.90 °F), but there's still a lot of contradictory research on the impacts of aerosols of clouds which can alter this estimate of aerosol cooling, and consequently, our knowledge of how many millions of tons must be deployed annually to achieve the desired effect.
- **Hydrological cycle**: Since the historical global dimming from tropospheric sulfate pollution is already well-known to have reduced rainfall in certain areas, and is likely to have weakened Monsoon of South Asia and

contributed to or even outright caused the 1984 Ethiopian famine, the impact on the hydrological cycle and patterns is one of the most-discussed uncertainties of the different stratospheric aerosol injection proposals. It has been suggested that while changes in precipitation from stratospheric aerosol injection are likely to be more manageable than the changes expected under future warming, one of the main impacts it would have on mortality is by shifting the habitat of mosquitoes and thus substantially affecting the distribution and spread of vector-borne diseases. Considering the already-extensive present-day mosquito habitat, it is currently unclear whether those changes are likely to be positive or negative.

**Other possible side effects**

Solar geoengineering in general poses various problems and risks. However, certain problems are specific to or more pronounced with stratospheric sulfide injection.

- **Ozone depletion**: a potential side effect of sulfur aerosols; and these concerns have been supported by modelling. However, this may only occur if high enough quantities of aerosols drift to, or are deposited in, polar stratospheric clouds before the levels of CFCs and other ozone destroying gases fall naturally to safe levels because stratospheric aerosols, together with the ozone destroying gases, are responsible for ozone depletion. The injection of other aerosols that may be safer such as calcite has therefore been proposed. The injection of non-sulfide aerosols like calcite (limestone) would also have a cooling effect while counteracting ozone depletion and would be expected to reduce other side effects.
- **Whitening of the sky**: Volcanic eruptions are known to affect the appearance of sunsets significantly, and a change in sky appearance after the eruption of Mount Tambora in 1816 "The Year Without A Summer" was the inspiration for the paintings of J. M. W. Turner. Since stratospheric aerosol injection would involve smaller quantities of aerosols, it is expected to cause a subtler change to sunsets and a slight hazing of blue skies.How stratospheric aerosol injection may affect clouds remains uncertain.
- **Stratospheric temperature change**: Aerosols can also absorb some radiation from the Sun, the Earth, and the surrounding atmosphere. This

changes the surrounding air temperature and could potentially impact the stratospheric circulation, which in turn may impact the surface circulation.

- **Deposition and acid rain**: The surface deposition of sulfate injected into the stratosphere may also have an impact on ecosystems. However, the amount and wide dispersal of injected aerosols means that their impact on particulate concentrations and acidity of precipitation would be very small.
- **Ecological consequences**: The consequences of stratospheric aerosol injection on ecological systems are unknown and potentially vary by ecosystem with differing impacts on marine versus terrestrial biomes.
- **Mixed effects on agriculture**: A historical study in 2018 found that stratospheric sulfate aerosols injected by the volcanic eruptions of Chicón (1982) and Mount Pinatubo (1991) had mixed effects on global crop yields of certain major crops. Based on several studies, the IPCC Sixth Assessment Report suggests that crop yields and carbon sinks would be largely unaffected or may even increase slightly, because reduced photosynthesis due to lower sunlight would be offset by CO2 fertilization effect and the reduction in thermal stress, but there's less confidence about how the specific ecosystems may be affected.
- **Inhibition of Solar Energy Technologies**: Uniformly reduced net shortwave radiation would hurt solar photovoltaics by the same 2-5% as for plants. the increased scattering of collimated incoming sunlight would more drastically reduce the efficiencies (by 11% for RCP8.5) of concentrating solar thermal power for both electricity production and chemical reactions, such as solar cement production.

# Appendix D Movement primer

## Experiment Condition 2 (intervention group)

*You have been randomly assigned to receive the intervention stimulus. Ideally, please read this ahead of the scenario exercise to be held 20/03/2024. Please also bring this with you for that session.*

*The following comprises selected extracts from a forthcoming educational movement primer on Stratospheric Aerosol Injection, written in collaboration with Climate Vanguard for the climate movement. Currently a work in progress, the final piece is subject to change. Please do not circulate this material. The completed*

*report will be published by June 2024, free to access for anyone on Climate Vanguard's website (https://www.climatevanguard.org/).*

**The Aerocene**

Existing scientific research on SAI can often yield contradictory results. This can be explained by studies assuming a standardised SAI deployment scenario whereby a certain amount of deployment masks a certain amount of heating. In fact, the lack of standardised deployment scenarios is revealing of a general immaturity of SAI research.

However, existing research, no matter how underdeveloped, makes clear that there are severe risks involved in the deployment of SAI.

**Contrails**

The injection of sulphate aerosols (sulphates) would lead to the reduction of ozone molecules, impairing the recovery of the ozone layer – ironically, this is one of the few achievements of international environmental governance. In turn, depleted ozone would increase the amount of solar UV radiation hitting earth, which is linked with increased rates of skin cancer.

Another primary public health risk of SAI deployment is air pollution. Injected sulphates would eventually fall back down to the surface, increasing fine particulate matter and degrading air quality. As the widespread combustion of coal shows, sulphates lead to increased rates of respiratory illnesses and mortality. Moreover, SAI can be 'deposited' in the form of acid rain, which negatively impacts "pristine" areas.

Public health impacts will get worse the longer SAI deployment lasts. More sulphate leads to coagulation, where molecules clump together to form blobs. Of course, these blobs are heavier than individual molecules, making them fall faster. If SAI is to remain effective in masking global heating, then coagulation would necessitate an increased sulphur payload, only leading to more coagulation, more pollution, and so on and so forth.

**Fallout**

In popular discourse, SAI is framed as a kind of global air conditioner that restores a comfortable temperature to Earth. The appeal hinges on the concept of restoration, the idea that SAI can bring us back to a planetary goldilock zone where human civilization once thrived. This represents the principal mischaracteriszation

of SAI: it does not restore pe-industrial planetary conditions but creates a no-analogue geoengineered Earth.

Understanding this requires a more nuanced depiction of SAI deployment. SAI would lead to an equal distribution of sulphates around the globe. However, solar radiation does not hit all areas of Earth in equal doses: more in the tropics than the poles, more in the summer than the winter, and none at night. In other words, an equal atmospheric distribution of sulphate is reflecting an unequal amount of solar radiation. This means that SAI would lead to the relative "overcooling" of the sun-bathed tropics and "undercooling" of the night-filled poles. The temperature gradient between the tropics and poles drives global weather systems. A flatlining would cause serious disruption.

A particularly distressing example is precipitation. Greenhouse gases trap heat, amplifying the hydrological cycle and the intensity of rainfall. On the other hand, sulphates would reflect sunlight and cool the planet, "[starving]" the hydrological cycle of energy. However, SAI would not reverse global heating's amplification of the hydrological cycle. Rather, it would "overcompensate" in the other direction, leading to a disproportionate reduction in precipitation. Summer monsoons in Africa and Asia, upon which billions of people depend, would be critically weakened.

Similarly concerning is SAI's impact on food production. In addition to fluctuating precipitation patterns, SAI would make incoming sunlight more hazy, posing serious risks to agricultural productivity. Any gains made from global cooling in the cultivation of maize, soy, rice, and wheat would be offset. Diffuse sunlight could also reduce the output of concentrated solar power, one of the most effective ways to produce solar energy at scale. And perhaps the most psychologically damaging: SAI would colour the sky a permanent milky white.

However, these impacts, disastrous in their own right, pale in comparison to the ultimate risk of SAI deployment: termination shock. Termination shock occurs when SAI is abruptly ended, leading to the rapid release of previously masked global heating. Depending on the accumulation of greenhouse gas emissions, termination shock could lead to a temperature increase of .5C/year or 4C/decade – a heating curve with "no precedent in the geological history of the climate". Such a rate of heating would eclipse the speed limits of life, leading to mass species extinction.

Even in the ideal circumstance that SAI is ended when CO2 levels have returned to the 'safe' level of 350 ppm, the termination of SAI would throw the planet out of its previous geoengineered state – by no means a smooth transition. As Malm puts it, humanity would be faced with a "roasting" or "reshuffling."

The roast could be caused by an assortment of unfortunate circumstances: a terrorist attack, war, pandemic, financial crash, natural disaster, revolution, or more befitting to a Marxist analysis, a strike along the SAI supply chains (certainly this merits a new category of the labour aristocracy). The reshuffle could be overseen by an assortment of eco-socialist regimes, who, by dint of democratic international planning removed hundreds of parts per million of CO2, and yet, are still tragically forced to wrestle with the decisions of "dead generations". The underlying truth remains: there is no return from the Aerocene.

## Capitalist Chronicles

We can only understand the rise of SAI if we understand its relationship to capitalism.

### Eternal Romance

The spatio-temporal advantages of fossil fuels (from the vantage point of capital) are still observable in contemporary capitalism.

First, large renewable energy installations effectively shackle capital to a specific geographic location, impairing its ability to scour the globe for cheap labour. Second, renewables remain prone to intermittency issues, posing problems for regular, on demand production. Of course, intermittency issues can be solved by setting-up renewable energy installations where the sun is always shining or wind is always blowing. But these types of large-scale projects require cooperation between capitalists.

Moreover, the actual production of fossil fuels remains more profitable than renewable energy. Renewables are more capital-intensive than fossil fuels, which means that capitalists need to invest a greater amount of money at the start of the project (as opposed to a more even spread of running costs). This breeds reluctance because of the inherent risks in relying on a volatile market to recoup a large upfront investment. This is further complicated by the razor-thin margins of renewables, a product of the low-entry barriers to renewable energy production. It is little wonder

then that 2.5% of fossil fuel company's capital expenditure goes to "clean energy technologies," the other 97.5% flowing straight into fresh fossil fuel extraction.

**Toxic Relationship**

Capitalism's dependence on fossil fuels is destroying the ecological basis for its reproduction. More specifically, the destruction of physical assets, losses in labour productivity, and shipping complications resulting from fossil-fuelled global heating are increasing the costs of production, eroding profit margins and weakening capital's capacity to accumulate. Losses in labour productivity are especially illuminating. Hotter weather makes people work slower, decreasing economic output. In fact, a recent report by the International Labour Organization finds that global heating will lead to the loss of 2.2% of total working hours, equivalent to 80 million full-time jobs.

But hot weather is not just a drag on labour productivity. It is also a deadly threat to workers, especially for those in outdoor sectors like transport, agriculture, and construction. Capital, especially in the Global North where more labour regulation exists, must respond to the occupational risks of increasing temperatures. Some companies are now planning to change their work hours to night or early morning to take advantage of cooler temperatures.

This is striking. Wasn't it the cotton capitalists of the early 19th Century who had to plan production around capricious weather patterns? Now the previous antidote – fossil fuels – are the cause of the atmospheric volatility. How will capital respond this time?

**Sulphate Therapy**

Capital is presented with three options. First, it continues to extract, pump, and burn ever-more fossil fuels, destroying the ecological foundation upon which it depends for reproduction. This is a path of self-annihilation.

Second, capital stops producing fossil fuels and initiates a global acceleration of renewable energy production. Not only does this go against its profit motive, but it would also expedite ecological collapse through precious metal extraction, leading to the same self-annihilatory outcome.

This brings us to the third option: capital briefly escapes its own internal contradictions through a technological lifeboat. Clearly, this lifeboat is SAI. It is a cheap, effective method of global cooling that can restore the ambient temperature required for unimpeded capital accumulation.

As the crescendo of global heating gets louder and louder, so do the ruling classes' muffled cries for dimming the sun. In June 2023, the White House released a report calling for a full-fledged research program on solar geoengineering. Soon after, it was the European Commission that called for global talks on the use of solar geoengineering. And, most recently, it is the ultra-wealthy European inlet of Switzerland proposing the creation of an expert UN advisory panel on solar geoengineering.

Sure, they're not saying 'it,' but their efforts at research and governance are the rhetorical equivalent of pouring the concrete, painting the stripes, and loading the planes. As the next section shows, it is this dual front for which movements must draw their battle plans.

This following section explores which stages of SAI development should be resisted. First the risks of researching SAI are explored followed by the challenges of democratically governing SAI.

**Front 1: Research**

More research leads to more knowledge, which leads to rational decision-making and secular progress. This is a dominant theory in bourgeois society. On its face, it makes sense. If we understand something better, then we can make more informed decisions. It is also the exact logic that proponents of SAI rely on: more research on SAI will lead to a more accurate understanding of its risks, providing a robust knowledge-base from which policy-makers can make rational decisions on development, deployment, and regulation.

But this is a mystification of how the real-world works. Decisions are not made on a rational analysis of existing knowledge, but in accordance with the *irrational* imperatives of capitalism. The global response to climate breakdown provides a lucid example. A brief glance at the past decades of climate failure shows that it is corporations, especially the fossil fuel industry, who have prevented climate policies that threaten their pursuit of profit – that is, any policy that would actually reduce emissions at the scale and pace required for a habitable future.

SAI won't be used to "shave the peak" off global heating to enable some kind of emergency decarbonisation program, as SAI proponents like Buck suggest, but to restore the necessary climatic stability for capital accumulation without stopping the growing combustion of fossil fuels. Of course, this is an untenable suturing of contradictions, one that will eventually implode under the weight of ever-worsening

ecological impacts inherent to long-term SAI. No amount of extra research changes this reality. Rather, additional research only strengthens the chances of deployment. A putatively sober analysis of a hypothetical 'solution' accrues increasing legitimacy, eventually snowballing into a viable emergency measure for an existential crisis.

Thus, additional research does not enable rational adjudication of SAI, but serves to legitimise its inevitably irrational deployment. Additional research efforts must be resisted. The thinking of Luke Iseman, co-founder of SAI 'start-up' Make Sunsets, plainly reveals this dynamic:

> "*If, with no strings attached, some oil company gave me 10 billion dollars and said 'quietly do deployment to half a degree Celsius,' I'd be lying if I were to say I wouldn't do it.*"

**Front 2: Governance**

An appropriate governance structure is a necessary prerequisite to begin safely engaging with SAI research. Such a structure would need to display the following characteristics:

**Democratic**

First, SAI governance needs to be democratic to the degree that the interests and voices of the global working and oppressed class – that is, the Global Majority – are represented. This is the most basic and crucial condition given the world-making effects of SAI deployment.

While a full review of democratic governance principles is beyond the scope of this report, such a structure must address two key aspects. First, it must have mechanisms for evening out power asymmetries between states, characteristic of the imperialist world-system. Second, it must meaningfully include the voices of stateless people, including Palestinian people, Sahawi people, Kurdish people, and Indigenous nations, among others.

**Universal**

Second, all states must be party to the governance structure. The characteristics of SAI make it amenable to unilateral deployment, particularly by rich countries. Any safe and fair governance structure must be universal, leaving no opportunity for a single-state or minority coalition to make such world-shaping decisions. This requirement becomes particularly necessary considering that the heterogeneous

effects of SAI would produce "winners and losers," creating an incentive for minority deployment by the 'winners' against the will of the 'losers.'

It should be noted that SAI proponents, disproportionately from the Global North, identify the possibility of unilateral deployment to be an *advantage* of solar geoengineering as it can be deployed in an emergency "without broad international cooperation". Existing enthusiasm for unilateral deployment reveals the imperative for an SAI governance structure to be universal.

**Enforcement mechanisms**

Third, any effective SAI governance structure needs appropriate enforcement mechanisms. Crucially, the strength of these mechanisms would need to be a historic first, robust enough to deter the most powerful nations from unilateral or minority coalition deployment.

With these three conditions established, we now explore the feasibility of such an SAI governance structure emerging.

SAI proponents often cite a variety of international climate governance structures to support the claim that an appropriate governance structure for SAI could be developed. Suggestions range from integrating SAI governance within existing institutions like UNFCCC or the UN General Assembly, to replicating the Montreal Protocol. None of these fulfil the three conditions outlined above.

On the democratic front, it is a recurring theme that the needs of the Global Majority are subordinated to interests of Northern governments and capital in international climate negotiations. This power-asymmetry is why the 2011 People's Agreement of Cochabamba called for the Global North to commit at least 6% of annual GDP to climate finance for the South, and yet all Northern states combined only conjured up $89 billion in climate finance for Southern countries in 2021 – 0.4% of the US' GDP that year.

Indeed, SAI proponents recognise that "the international system is undemocratic in sometimes contradictory ways." However, they deploy this in justification of pressing ahead with undemocratic SAI deployment, rhetorically asking, "is democracy everywhere not circumscribed by wealth and power?" In so doing, they reveal their fundamental commitment to reproducing existing power imbalances instead of acknowledging and addressing the systemic drivers of climate breakdown. Ultimately, international governance structures which don't address the

material power imbalances between states and feign equal representation of the Global Majority, “the force [of imperial powers] will decide.”

On the universality front, international climate agreements have a spotty record. They have particularly, and not coincidentally, struggled to reign in the world’s largest emitter: the US. The US never ratified the Kyoto Protocol, nor the Convention on Biodiversity, and also temporarily left the Paris Agreement under Donald Trump’s presidency.

Only the Montreal Protocol received universal ratification. Indeed, it stands out as the first and only international environmental agreement to have reached 197 state signatories. However, the Montreal Protocol was unique in that it focused on the phase out of chlorofluorocarbons – an ozone-depleting chemical that was easily replaceable in production processes, and in turn, had little impact on capital accumulation. This stands in stark contrast to climate change agreements as fossil fuels are not easily replaceable in the capitalist world-system without dramatically disrupting capital accumulation. Indeed, this helps explain the success of the Montreal Protocol and the failure of the Kyoto Protocol.

As outlined in *Capitalist Chronicles*, SAI is, at its core, a non-substitutable technology which, like fossil fuels, is also fundamentally bound up in the process of capital accumulation. As such, the universality of the Montreal Protocol is hardly applicable to a potential SAI governance structure.

When it comes to regulating processes intimately involved with capital accumulation, it is only when the agreements are non-binding that the most powerful countries agree to join.

On the enforcement front, the inadequacies of existing climate governance structures are pervasive. Without enforcement, countries break pledges with impunity. While the 2015 Paris Agreement outlines that signatories are committed to “limiting global temperature increase to well below 2 degrees Celsius, while pursuing efforts to limit the increase to 1.5 degrees,” current emissions reduction plans under the Paris Agreement would lead to 2.5C to 2.9C heating.

Importantly, it is no coincidence that there has never existed a governance model which appropriately fulfils the necessary conditions for SAI governance. Such a structure is antithetical to global power arrangements under capitalism by directly contradicting the interests of the ruling class. In the case of SAI specifically, democratic participation and just deliberation would involve an interrogation of the

atmospheric commons including the colonisation of the atmosphere, the need for climate reparations, and a general critique of global imperialism. SAI *requires a lack of participation* for it to be effectively deployed by the ruling class as a spatiotemporal fix to capital-driven climate breakdown.

On this basis, it is clear that a governance structure which includes the necessary degree of democracy, universalism, and enforcement mechanisms is not possible in the capitalist world-system. Absent such a governance structure, SAI can be understood as a form of "stratospheric imperialism." SAI does not set out to control the land as in traditional imperial pursuits, but to control the atmosphere which is just as much part of the environment. Manipulation of the weather system to maintain existing patterns of capital accumulation, at the cost of uneven global impacts assumes a "natural" ownership of the climate by developed nations, which can only be understood as imperial domination of the atmosphere.

# Appendix E Scenario task

## Stratospheric Aerosol Injection Scenario Exercise

*Year: 2029*

In the wake of five consecutive years of escalating temperatures, the discourse surrounding Stratospheric Aerosol Injection (SAI) has reached a fever pitch. Debated fervently by academics, politicians, and activists alike, the concept of SAI has surged to the forefront of discussions on climate intervention. Now, breaking news reveals that the United Kingdom's government has commissioned a task force of advisors, their goal is to determine and elaborate details of stratospheric aerosol injection deployment, or a rationale to oppose such action. You are that task force.

- **Your Task:** As a member of this task force, your mandate is broad and far-reaching. It may include but is not limited to:
    - A plan *for* SAI deployment and/or further research, detailing rationale.
    - A discussion *against* SAI deployment and/or further research, detailing rationale.
    - A proposed system of governance of SAI. Elaborating on details such as what bodies (new or already existing) have authority over

both deployment and research, who does or does not participate, how decisions are made. Please be specific in this elaboration, thinking at whichever scales you deem suitable.

- A problematisation of governance, elaborating on what issues are foreseen with the development of such structures.

You have 30(ish) minutes for this task, feel free to work within your assigned group, or independently. Please document your key points and positions on the paper provided.

# Appendix F Codes

| Name | Files | References |
|---|---|---|
| Laughing at suggestion to advice to disband capital | 1 | 1 |
| International focus necessary | 1 | 3 |
| Lack of education | 1 | 12 |
| Radical social movement | 1 | 7 |
| Reform social democracy | 1 | 5 |
| Citizens assemblies | 1 | 1 |
| Citizens assembly limited in transformative power | 1 | 3 |
| Dialectics and organisational building benefits | 1 | 3 |
| Climate justice | 1 | 2 |
| Cost benefit analysis | 1 | 1 |
| Damage limitation | 1 | 2 |
| Economically viable | 1 | 1 |
| Governance framework needed | 1 | 2 |
| IPCC or WHO deployment | 1 | 2 |
| Not necessarily political but will be in practice | 1 | 1 |
| Petro state support | 1 | 1 |
| Publicly funded and overseen programme | 1 | 2 |
| Technocratic approach | 1 | 2 |
| Things to consider | 1 | 1 |
| UN governance | 1 | 1 |
| Intervention group | 1 | 1 |
| Cannot be democratic in capitalism | 1 | 2 |
| Climate justice of concern | 1 | 4 |
| Concerned about research | 1 | 2 |
| Damage limitation (2) | 1 | 1 |
| Democratically decided and binding | 1 | 3 |
| Hopelessness | 1 | 3 |
| Dire situation use | 1 | 1 |
| Does not trust UK gov to not listen to issues of climate justice | 1 | 4 |
| Mitigation deterrence | 1 | 2 |
| No deployment no research | 1 | 2 |
| Not possible to get all countries to sign up | 1 | 2 |

| | | |
|---|---|---|
| Objectivity vs positionality | 1 | 4 |
| SAI not necessarily problem but capital is | 1 | 3 |
| Very complicated | 1 | 1 |
| Very concerned | 1 | 3 |
| Feeling toward SAI prior intervention | 0 | 0 |
| Could be positive | 1 | 2 |
| Damage limitation | 1 | 3 |
| Decent understanding | 1 | 1 |
| Inevitable deployment | 1 | 2 |
| Limited knowledge | 1 | 1 |
| Mitigation delay worry | 1 | 3 |
| More likely in political reality | 1 | 7 |
| One state deployment | 1 | 3 |
| Perhaps other geoengineering ideas | 1 | 1 |
| Radical action first | 1 | 1 |
| Split in the movement | 1 | 2 |
| Technocratic | 1 | 1 |
| No change then a lot | 1 | 3 |
| Feeling that climate movement won't create change in time | 1 | 2 |
| Climate change fell into culture war | 1 | 1 |
| Greenwashing | 1 | 2 |
| No stick to change capital | 1 | 6 |
| Personal responsibility | 1 | 3 |
| Individualism as driver | 1 | 1 |
| Systemic overhaul necessary | 1 | 12 |
| Technological innovation required | 1 | 5 |
| Listen to the science | 0 | 0 |
| Crisis is now | 1 | 3 |
| Palestine Movement | 1 | 1 |
| Palestine violence clearer | 1 | 5 |