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Debate

Geoengineering: Re-making Climate for Profit or Humanitarian Intervention?

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ABSTRACT

Climate engineering, or geoengineering, refers to large-scale climate interventions to lower the earth's temperature, either by blocking incoming sunlight or removing carbon dioxide from the biosphere. Regarded as 'technofixes' by critics, these strategies have evoked concern that they would extend the shelf life of fossil-fuel driven socio-ecological systems for far longer than they otherwise would, or should, endure. A critical reading views geoengineering as a class project that is designed to keep the climate system stable enough for existing production systems to continue operating. This article first examines these concerns, and then goes on to envision a regime driven by humanitarian agendas and concern for vulnerable populations, implemented through international development and aid institutions. The motivations of those who fund research and implement geoengineering techniques are important, as the rationale for developing geoengineering strategies will determine which techniques are pursued, and hence which ecologies are produced. The logic that shapes the geoengineering research process could potentially influence social ecologies centuries from now.

INTRODUCTION

The storyline in most media coverage is that climate engineering used to be considered a fringe idea, but is now starting to receive serious consideration as prospects for policy action to reduce greenhouse gas emissions dim. Since the atmospheric scientist Paul Crutzen (2006) broached the topic of releasing sulphates into the stratosphere in a *Climatic Change* editorial essay, there has been increasing debate among scientists about the idea. In 2009, the UK's Royal Society released the seminal report 'Geoengineering the Climate: Science, Governance and Uncertainty', which introduced the concept of geoengineering to policy makers. The Royal Society report divided geoengineering into two basic methods: solar radiation management (SRM) and carbon dioxide removal (CDR). SRM, or sunlight reflection methods,

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would reflect incoming solar light and heat back into space. These strategies range from the fairly down-to-earth (painting roofs white) to the grandiose (placing reflectors in space). The two most commonly floated techniques are to enhance the brightness of marine clouds using specially designed ships or to release aerosols into the stratosphere; the particulate matter would create global dimming much as a volcano does. Carbon dioxide removal, on the other hand, would deal directly with the carbon (im)balance by removing carbon dioxide from the atmosphere. Methods include afforestation and land use management to enhance carbon sinks; increasing the oceanic uptake of CO_2 by ocean fertilization or wave upwelling; biochar, the enhanced weathering of carbonate or silicate rocks; or direct capture of CO_2 from the air. The Royal Society report classifies CDR methods as being safer, but slower to take effect; SRM is considered cheaper, quicker and more risky.

Governments and policy makers in Europe and North America are increasingly aware that they will have to seriously consider geoengineering in the near future — whether to pursue research or to ban the application of geoengineering techniques altogether. Two UK Research Councils have funded geoengineering projects — the Integrated Assessment of Geoengineering Proposals (IAGP), and the Stratospheric Particle Injection for Climate Engineering project (SPICE) — while the US Government Accountability Office recently released a review of geoengineering research in the US and recommended a clear, coordinated US government strategy on research (GAO, 2010). Geoengineering has been the topic of committee hearings in both the US House of Representatives and the UK House of Commons; on a multilateral level, geoengineering was assessed for the first time in the Fifth Intergovernmental Panel on Climate Change report (IPCC, 2010). These assessments, however, have not yet led to clear actions, as virtually no government is enthusiastic about the complexities involved. If reaching international agreements on curbing greenhouse gas emissions is difficult, reaching consensus on how to engineer the climate could also be a policy, and legal, quagmire. There is no established governance regime for research or the potential use of the technologies under investigation, though some existing international treaties could apply to certain aspects of it. Most research is being conducted in the lab, using computer models, with low funding. The interest in geoengineering is a quiet interest: there are serious reservations about the wisdom of attempting to modify the climate through technology, and there is uncertainty about public reaction to the concept. As researcher Ken Caldeira has said, 'only fools find joy in the prospect of climate engineering' (cited in Williamson, 2011: 18).

Still, unless these technologies are rejected by scientific or political consensus, and pending a major social shift in attitudes towards fossil-fuel consumption, sober interest in them is likely to grow. Geoengineering technologies also have strong humanitarian implications. Should they work well, and help to alleviate drastic climate change, they could

potentially mitigate the suffering of many, including those most vulnerable to climate change. Should they fail — for example, weakening the south Asian monsoon (see Robock et al., 2008), changing precipitation in the Sahel, or bringing about other unforeseen consequences — they could result in humanitarian disasters. Therefore, development studies scholars and practitioners should be aware of geoengineering research and development, as climate engineering could hold promise and peril for vulnerable populations.

The promise of geoengineering is rarely discussed in development circles, perhaps because large-scale climate modification is so questionable. There are concerns about whether humans have the skill, or even the right, to intervene in such a complex system. Many organizations focused on environmental or social justice are questioning whether geoengineering may be — unintentionally or even by design — a class project which would allow a 'business as usual' fossil-fuel regime to continue chugging along for the benefit of a small elite. Discussing geoengineering has a place within debates about nature, capitalism, climate change and climate justice, with links to several theoretical perspectives on nature–society relations. Geoengineering may be contentious to those who seek a de-growth model on ecological grounds, as it seems to expand the limit of carbon sinks to act as a waste frontier. It is also of interest to those who study inequality in resource use, particularly from world-systems or historical materialist perspectives, as geoengineering seems to imply that consumers in the North would be able to continue their excessive use of energy due to the possibilities that geoengineering might offer. Following metabolic rift theory, geoengineering would attempt to fix an 'ecological rupture' in the metabolism of a system, where natural cycles are interrupted. According to Clark and York (2005: 399) the metabolic rift is created by capitalism, and as capitalism develops, the rift in agriculture intensifies and creates rifts in other sectors of the society–nature relationship. While previous writers from Marx (1981/1894) to Foster (2011a) have focused on agriculture and replacement of soil nutrients, Clark and York have shown that the theory is applicable to the carbon cycle at large and to global climate change. This evokes concerns that geoengineering might serve as an unequal (and ultimately unworkable) fix to this metabolic rift, and prolong or exacerbate social inequalities in the process. From an ecological Marxist perspective, geoengineering also appears as a workaround for the second contradiction of capitalism — capital's tendency to destroy its surroundings and undermine its own conditions of production (as described by O'Connor, 1998).

This article departs from the assumption that there is a 'direct and growing contradiction' between capitalism and the environment as Bellamy Foster (2011b) puts it. Since capitalism is aimed at exponential growth, and the earth has physical and biological limits to what it can provide and absorb, we must shift towards a sustainable steady-state economy. How geoengineering might interfere or play a role in this shift is the subject of this

contribution. The first section explores whether concerns that geoengineering will enable capitalism to continue to grow are credible. We begin by reviewing three key sources for social justice concerns with geoengineering: the historical entwinement of weather control with military schemes and entrepreneurial dreams of increased crop production; the idea that geoengineering is a substitute for emissions reduction; and the concept that geoengineering is coupled with ineffective market fixes for climate change. The analysis finds that while it may be of benefit to fossil-fuel capitalism, geoengineering research and development is not at present highly driven by capital interests. The second section of the article looks at an alternative, humanitarian rationale for geoengineering research and assesses the possibility of a geoengineering regime emerging which is driven by humanitarian logic and implemented through development and aid institutions. The article concludes by exploring the possibilities of a socially transformative geoengineering.

OPPOSING GEOENGINEERING

The History of Geoengineering: Climate as Politics by Other Means?

Scepticism about commercial or aggressive intervention in the climate system may spring from its historical precedents. Clausewitz (2007/1832) may not have foreseen the Anthropocene, but a world in which weather control is a political game, where the climate is the latest sphere in which to play out geopolitical rivalries, is not altogether inconceivable. Weather control has roots in both Cold War rivalries and post-World War II commercial endeavours to grow crops. In the early 1950s, ranchers, farmers and public agencies were enthusiastic about the idea of making rain to increase crop production. The Soviets entertained grandiose visions of increasing temperatures in Russia by warming Arctic sea ice or injecting metallic aerosols into orbit to form rings (Keith, 2000: 251). In the US, military schemes like Project Stormfury and Project Climax sought to control hurricanes and increase the Colorado snowpack. In fact, Strategic Air Command General George C. Kenney proclaimed that 'the nation that first learns to plot the paths of air masses accurately and learns to control the time and place of precipitation will dominate the globe' (cited in Fleming, 2006: 10). It was actually the backlash against Operation POPEYE, a secret cloud-seeding operation in Vietnam, which helped provoke the 1978 UN Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD). The operation lasted from 1967 to 1972 and involved 2,600 sorties at a cost of about US$ 3.6 million per year (Fleming, 2006: 13). At that time, the fact that weather modification didn't work as well as its proponents had hoped dissolved some of the exuberance about its commercial potential, and the cultural shifts and counter-industrial narratives

of the 1970s made the idea of weather modification problematic (Kwa, 2001: 151).

Criticism of the mentality of climate control goes beyond critiques of the twentieth-century military–industrial complex. The ETC group, an NGO concerned with technological and environmental change, considers geoengineering 'a philosophy and a world view that is heavily coloured by a Western, male-dominated, narrowly scientific paradigm that fails to recognize its own epistemic position of privilege … seeing our ecosystems as resources to be optimized or "fixed" rather than systems to be protected and restored' (ETC Group, 2010: 6). Critics see geoengineering as just the latest chapter in a long story of command and control, which includes Francis Bacon's sordid attempts to wrest the secrets out of Mother Nature (cf. Merchant, 1980), Descartes' *maîtres et possesseurs de la nature* (masters and possessors of nature) (1999: 44), as well as Hobbes (2002/1651), Rio Tinto, Monsanto, and a network of other connected referents.

A Substitute for Reducing Emissions (And a Chance for Continued Growth)?

A more specific concern about geoengineering is that it potentially offers a means to avoid reducing growth, and keep up the pace of 'business as usual': that is, geoengineering could act as a substitute for emissions reduction. There are two related dimensions to this concern. The first is the idea, formulated by scholars in many fields, of 'moral hazard' — that geoengineering would reduce the motivation to cut emissions and thus end up becoming a substitute for emissions reduction. The second dimension has been grafted onto the first basic argument: that geoengineering would be a substitute for reducing growth. If one accepts the position that reducing emissions will mean reducing growth, this is a logical extension. We will first examine the broader concern, and then its corollary.

The Moral Hazard

Against the moral hazard argument, Humphreys poses the question, 'Would states have agreed on tougher measures to reduce greenhouse gas emissions, had geoengineering not existed as a theoretical possibility? There is little evidence to suggest that this would be so' (2011: 111). Climate negotiations are stumbling enough on their own without geoengineering to compromise them. Or, as Bunzl (2009: 2) writes, 'it is hard to discern why moral hazard should function as a deterrent to action here anymore than it does elsewhere'. Bunzl (ibid.) continues:

> Moral hazard only arises for geoengineering if you think that research or, if it came to it, implementation, would undermine other actions and lead to more not less greenhouse gas

> output. That seems farfetched since, at least among policy makers, nobody believes that geoengineering offers anything but a relatively short stopgap to buy time for other action. Nor are the funds that would be needed for geoengineering research large enough relative to the research budgets of even the United States, let alone the whole developed world, to create an allocation issue.

Humphreys and Bunzl have a point. There is near consensus among scientists that geoengineering is not a substitute for emission reductions. Many atmospheric scientists have worked hard to stress to policy makers that geoengineering is flawed — by no means a 'silver bullet'— and that geoengineering research must take place in a context of climate change management that includes mitigation and adaptation measures (GAO, 2010; Royal Society, 2009; Vaughn and Lenton, 2011; Wigley, 2006).

However, moral hazard could play a significant role when it comes to investment in future energy projects. While no scientist suggests that geoengineering would be a substitute for emissions reduction, what matters in the world of the market is the narrative, the image, the market signal, the confidence level — not the reality. It hardly matters that geoengineering cannot actually be a substitute for emissions reduction if enough investors or corporate leaders *believe* it can and invest heavily in extreme energy projects — that is, if the geoengineering discussion creates the *perception* that regulation can be avoided and fossil-fuel prices kept high. As Naomi Klein has observed, 'we have exhausted business as usual and moved to the "era of extreme energy"' (2011). Fracking, tar sands, deepwater and floating liquid natural gas facilities are hallmarks of this era. These are technologies that require large upfront capital investments to get off the ground, and companies might be skittish about making these financial commitments if they knew that stringent carbon regulation was looming which would reduce demand for fossil fuels. The financial crisis curbed investment in extreme energy: in 2009, project delays and cancellations due to lower cash flow cut global upstream oil and gas investment budgets by around 19 per cent on the previous year, a reduction of over US$ 90 billion, with oil sands projects in Canada accounting for the majority of suspended capacity (IEA, 2009). This demonstrates that extreme energy projects require a sustained commitment from large capital inflows. If geoengineering research was seriously funded by governments or was positively argued for in international negotiations, combined with a lack of progress on green energy finance or emissions cuts, this could theoretically send market signals that might increase investor confidence in extreme energy. Hence, the idea of geoengineering, or perceptions about its potential, could be more dangerous than the reality of it. There is also a danger that with investment commitments in extreme energy, vested interests could become even more pronounced, unleashing a cycle in which interested parties may call for geoengineering approaches to protect these new financial commitments to unconventional energy.

Beyond the Moral Hazard: Saving Growth for One More Round?

A follow-on to the moral hazard concern is that geoengineering would be a substitute not only for reducing emissions, but also for reducing growth. Corner and Pidgeon (2010: 31) write that 'for groups and individuals who see climate change as the symptom of a social and economic order that is inherently unsustainable, geoengineering represents the worst kind of techno-fix'. The ETC Group frames the climate change problem as requiring an either/or response: developed countries can either adopt policies to curb fossil-fuel use, 'or they can hope for an alternative — a "silver bullet" in the form of an array of techno-fixes that will allow them to maintain the status quo and dodge the consequences' (Bronson et al., 2009: 5). The economist Herman Daly (2011) is concerned that 'panicky protectionist interventions by arrogant geo-engineers to save growth for one more round will just make things worse'.

However, most 'geoengineers' are scientists who are in a position to be seriously concerned about the climate, as they understand the technical issues; by and large they have no macro-economic agendas. To lump these actors together — atmospheric scientists and people trying 'to save growth for one more round' — is to misconstrue the actor coalition. This is not just an analytic mistake but a tactical one, as atmospheric scientists are potentially powerful allies of those seeking solutions to climate change. However, if there was an actor trying to 'save growth for one more round', who might it be?

Climate change poses at least two threats to vested business interests: disruption to the existing fossil-fuel based business climate from increased regulation or carbon taxes (bearing in mind that disruption of fuel prices reverberates throughout production chains), and disruption to the actual climate system, with the myriad of impacts that this would have on agriculture, shipping, etc. — i.e. the conditions of production. Vested interests might seek to stabilize both these threats, but it is the first — avoiding regulation on fossil energy — which would most capture business interest, especially from the energy, finance or transport sectors, seeking to maintain production levels. For the most part, business is not unified or forward-thinking enough to conceive of and collaboratively react to the second danger, disruption to the actual climate, save for segments that are in the frontline of the impacts of climate change, such as the insurance sector.

Swyngedouw (2009: 16) writes that 'stabilizing the climate seems to be a condition for capitalist life as we know it to continue'. Ecological Marxists have recognized the climate system as an environmental condition for production and, as Bryant (2011: 6) notes, a productive force. This is true, especially since cheap food is difficult to produce in an erratic climate — but that does not mean that 'capital' is conscious enough to realize that it needs a stable climate. 'Capitalism does not work when it comes to protecting our climate, because it is "flying blind". . . it lacks the sensory organs that

would allow it to understand and adjust to the climate system', writes Storm (2009: 1016–17) (following Speth, 2008). As capitalism is an 'externalizing machine', the system as a whole will not observe and respond to externalities like climate change. While problems for capitalism have historically been remedied by innovative entrepreneurs, or class–state alliances and social measures that supported workers, climate change will not be easily negotiated as it involves complex natural systems and a much longer time horizon than capitalism's previous crises (insufficient demand, overproduction, and so forth).

Those who believe that geoengineering could be a substitute for something — a 'cheap fix' — might be intuiting that geoengineering could be a metabolic fix. Foster (2011a) expands on Marx's (1981/1894) comments on the estrangement of human beings from the land, and from nature: 'The labor process itself [Marx] defines in *Capital* as the process by which people carry on the metabolic relationship between nature and society … In other words, labor is how people transform nature for society and he saw this as a metabolic process' (Foster, 2011a: 129). These labour-intensive metabolic processes — chiefly, agricultural production and energy production — have become unbalanced in the industrialized era, with fossil-fuel based intensification of agriculture and energy generation allowing humans to appropriate amounts of nature disproportionate to the labour required. Some geoengineering strategies, such as stratospheric aerosol injections, would not be sustainable solutions to this metabolic imbalance, as they would not deal directly with imbalances in the carbon and nitrogen cycles. Other climate remediation strategies, such as afforestation and some of the other carbon dioxide removal strategies, could bring about genuine metabolic repair, as they would directly address imbalances in the carbon cycle.

Returning to the theme of alienation, of labour mediating the relationship between humans and the land, there are geoengineering strategies that perpetuate this alienation from the land, but there may be others that ameliorate it. If we were all to take part in the local biochar processes, or invest our time in afforestation, it might actually bring about a decrease in alienation for many of us. The impulse to engineer, to make or re-make nature, need not be 'interventionist', with all the negative connotations the term carries; it could be the positive intervention of people who are designing their habitats, with an eye for beauty. There are other cultural patterns that factor into our nature-making besides the desires for control or profit. This is apparent in the way children build sand castles, gardeners pore over seed catalogues, or people paint their homes.

In sum, geoengineering is not a physical substitute for emissions reductions, but the *idea* that it could be might pose a kind of moral hazard. While a few economists have suggested that geoengineering could substitute for emissions reductions (e.g. Barrett, 2008; Levitt and Dubner, 2009), most scientists (e.g. Vaughn and Lenton, 2011; Wigley, 2006) have been explicit in stating that it cannot.

Geoengineering: A Place in the Market?

Geoengineering is criticized for being inextricably linked to market fixes for climate change. The carbon market would produce the commercial incentive for geoengineering to take off as a for-profit activity; geoengineering needs a carbon market to be profitable. As one radical newspaper sees it:

> The wealthy and powerful have succeeded in blocking, for now, the shift to a society, economy and polity that sustains the vast breadth of humanity and the planet. Instead, we will be given shoddy fixes. One will be a technological fix, geoengineering, which has been described as 'hacking the planet'. The second will be a market fix, cap and trade, which aims to turn pollution into a tradable commodity in a new privatized atmosphere. The aim of both is to sustain extractive industries, the fossil-fuel economy, consumer capitalism and globalized inequality and deprivation. (Gupta, 2009: 10)

Now that nature has been degraded, is there a market opportunity in remaking it? Could climate change be crisis-as-opportunity for capitalism? Are we witnessing an incredibly adaptive system transform itself yet again? Potentially, geoengineering could work with green technology (remaking places and ecosystems destroyed by degradation and climate change, *à la* disaster capitalism) to fuel a new global economic upturn, a new wave of accumulation. Kondratieff waves describe 40–60 year cycles in the global capitalist economy; previous 'techno-economic paradigms' have crested upon Fordist technologies and organizations of production, cheap oil and information technology. Financialization and geoengineering together could represent a new wave for a new 'green' economy: as Moore (2011: 4) observes, 'financialization presented a remarkable solution to the withering marriage of plunder and productivity marked by the progressive closure of frontiers'. One could say that a waste frontier is closing: it is becoming less possible, because of absorption capacity (and, potentially, regulation) to continue to emit greenhouse gas wastes. In theory, successful financialization of carbon, together with geoengineering, could do more than merely allow for continued plunder and production: they could surpass the status quo to become a force for innovation, generating new technologies and new capital accumulation.

In spite of fears that CDR techniques could be used to create credits to sell rather than to combat global warming, carbon trading has not taken off. Castree observed that 'recent arguments that immediate investment in "clean tech" industries could spark a new Kondratieff wave for Europe have so far fallen on deaf ears — if not intellectually, then practically' (2009: 205). There were estimates that a carbon market could approach US$ 1.2 billion by 2012 if the US passed cap-and-trade legislation, but that now seems dead in the water, although efforts continue in other places such as Australia. Profit from most geoengineering ventures would require a stable carbon price. Furthermore, depending on the techniques chosen, geoengineering could work against clean technology and actually halt a Kondratieff wave predicated on clean technology growth.

If private geoengineering investment is not forthcoming from those who hope to capitalize on carbon trading, are there other streams for investment in geoengineering technologies? One might expect energy companies to be involved in financing research, but there is little indication of this. The ETC group believes that energy, aerospace and defence enterprises are 'remaining in the background, for now', but once 'others deliver the "shock" — that climate chaos is upon us and GHG emissions won't be reduced in time — industry can deliver the "therapy" of techno–fixes that will alter the stratosphere and/or restructure ocean surfaces to ostensibly buy us more time' (ETC Group, 2010: 1). This is a possibility, but it is far from a certainty. There are plenty of reasons why energy, aerospace and defence enterprises would not want to become involved in geoengineering: it is politically dangerous, its profitability is questionable, compared to the profits they already make, and it might not even work. For defence industries, there are plenty of other revenue streams in an insecure twenty-first century. Moreover, the amount of geoengineering technology, products or services required has natural and carefully calculated limits, compared to the massive infrastructure of existing defence, aerospace and energy projects: Robock et al. (2009: 3) have suggested that as a few as nine KC-10 extender planes could be used to implement sulpheric aerosol injection. Geoengineering may end up being small business — too small for a capitalist rationale to act as major research and development driver.

GEOENGINEERING FOR PEOPLE IN NEED

It is arguably warranted to intervene in a complex system where people are suffering and such an intervention is humanitarian in nature. At the time of writing, policy makers are struggling to muster a response to the catastrophic drought in the Horn of Africa, while assessing the result of humanitarian intervention in Libya and debating if any intervention is called for with respect to the repressive regime in Syria. There has been criticism for intervening, and criticism for failing to intervene. The ghosts of the past two decades line up to be counted: from Srebrenica to Rwanda, Operation Uphold Democracy to Darfur. Yet in general, humanitarian interventions do garner support. Geoengineering is contentious in part due to its frame as an 'environmental' intervention, since environmental interventions have a tarnished history. However, as climate change begins to affect both natural and social systems, these 'humanitarian' and 'environmental' interventions may move closer to being the same thing. In this section, we will consider how geoengineering could be driven by a humanitarian rationale, and developed and implemented by the humanitarian sector. First, we will look at the reasons why a humanitarian approach may be adopted; next, we will examine how it may be implemented; and finally, we will evaluate the dangers and potentials of a humanitarian approach.

The Polluter Pays, the Responsibility to Protect and Other Ethical Principles

The first reason why geoengineering might be driven by a humanitarian rationale is simply the prospect of a climate emergency. Models indicate that climate change from increased greenhouse gas levels is largely irreversible for 1,000 years after emissions stop; if anthropogenic radiative forcing were stabilized, atmospheric warming would continue for centuries while the climate system reaches a balance (Solomon et al., 2010). Hence, some argue that geoengineering is needed to deal with the warming from the carbon that has already been emitted. If the more grim scenarios come to pass, the resultant warming may produce widespread calls for geoengineering on humanitarian grounds. Humanitarian discourse has often served as a meeting place where different perspectives can agree on the need for action, from religious actors and environmentalists to World Bank economists.

However, there are also ethical principles that could encourage geoengineering for humanitarian reasons. It is already accepted by many that rich countries have an obligation to help poorer countries in adapting to climate change, under the 'polluter pays' principle, as most emissions have historically come from rich countries: this obligation could encompass geoengineering. A presentation in 2008 by leading atmospheric scientists raised this possibility: 'Yet, despite uncertain and very negative potential consequences, geoengineering might be needed to avert or reverse some dramatic change in the climate system, such as several meters of sea level rise that could impose disaster on hundreds of millions of people' (Ricke et al., 2008). If geoengineering was pursued by wealthier nations on behalf of those vulnerable millions, it could be seen as a humanitarian act in which the polluters attempt to alleviate the damage they have done. Even the environmental NGO, Friends of the Earth, states that 'large amounts of chemical air capture of carbon and storage — funded and carried out by rich countries — will probably be necessary, as long as safe storage sites can be identified and governance issues addressed' (Friends of the Earth, 2009: 5).

Geoengineering projects with humanitarian approaches could also be demanded under the principle known as 'responsibility to protect'. Humanitarian and governance practitioners Suarez, Blackstock and van Aalst, in what may be the first consideration of a humanitarian-centred geoengineering framework, write:

> The underlying premise of R2P is that if any country is unable (or unwilling) to protect its citizens from severe threats to their physical wellbeing, then the international community has a responsibility to intervene and provide, as best as possible, that protection for the population . . . In this context, if geoengineering techniques might provide a means for avoiding some of the worst climate-induced suffering of these populations — which would otherwise have no protection — does the international community have a 'responsibility' to explore and develop them? (2010: 3)

The authors acknowledge that 'codifying and operationalizing a principle similar to R2P in the context of environmental and climatic threats would present enormous challenges' (ibid.). However, mass media coverage of climate disasters and the desperate need to act provide motivations to work though these challenges. 'Climate poverty' could become part of a new lexicon, along with 'energy poverty': conditions in which people lack access to the climate or the energy required to sustain their basic human needs. Such suffering could shift climate change from being an economic or scientific problem to being a humanitarian disaster, and geoengineering could become one critical response.

Implementing a Humanitarian Version of Geoengineering

The distinction between a humanitarian response and development programmes would become blurred, as geoengineering research and development guided by this sector would contain elements of both: long-term programmes inspired by an emergency mentality. This is a logical extension of the preparations humanitarian agencies are already making with regard to climate change adaptation. Many multilateral organizations such as the UNDP, UNEP and World Bank have extensive climate adaptation programming, which finance ecosystem restoration, community capacity building and resilience, and disaster response. Aid agencies already finance climate change-related development projects. The line between adaptation and geoengineering is not always clear, especially when it comes to afforestation and other carbon management projects, and a recent report for policy makers recommended giving more attention to 'geoadaptation': regional efforts that could be applied 'as needed', for example, to halt sea level rise and polar melting (Olson, 2011: 42). McMichael (2009: 252), following Klein et al. (2008: 2), points out that help with adaptation is often considered a moral responsibility by carbon-emitting countries, and can be 'similar to, and sometimes indistinguishable from, development'. He observes that development agencies and NGOs could use their experience in poverty alleviation to assist less developed countries in adapting, employing insurance schemes, crop-rotations, drought-resistant seeds, and sea defences. Hence, a geoengineering–development regime could emerge which has much in common with existing systems and projects.

The challenge, of course, is finance. Humphreys (2011: 133) poses the question, 'Who will pay the least developed countries to implement territorial geoengineering? The main alternative to the market is international public finance'. The Nobel laureate economist Thomas Schelling has acknowledged that dealing with climate change will require transferring resources from the rich to the poor. He suggests that international climate

agreements will 'require something like what was done at Bretton Woods in 1944, in establishing the International Monetary Fund and the International Bank for Reconstruction and Development', to set up a successful climate regime (Schelling, 2009: 105). It is possible that the urgency of the situation may lead to the creation of a new, comprehensive agreement that goes beyond the current discussions on climate finance (such as the US$ 30 billion of fast-start financing pledged in the Copenhagen Accord, the Green Climate Fund, etc.) to establish a climate and development finance regime that includes geoengineering.

Perils and Potentials of a Humanitarian Approach

Establishing a humanitarian geoengineering regime is not without its risks, as aid can become a tool of business interests. Many humanitarian actions have already been interpreted as class projects: tied aid with weak, unenforceable conditionalities, neoliberal structural adjustment programmes and 'disciplining' of economies. Yet many class projects do have a genuine humanitarian dimension. From structural adjustment to carbon adjustment, the distinction between helpful intervention and opportunism can be blurred.

There have been some stark indications of the potential for business to capitalize on climate-related disasters. Agricultural technology and biofuels provide some disheartening examples of corporations seizing upon the commercial potential of climate change. As McMichael (2009: 252) writes, 'Climate proofing is a new profit frontier . . . At a time when flexible seed selection by farming women in West Africa, for example, has managed recurring drought, gene patents threaten farmer sovereignty, and shift resources away from farmer-based strategies for survival and adaptation'. He cites NGO claims that the top ten seed companies control 57 per cent of the global seed market: 'As climate crisis deepens, there is a danger that governments will require farmers to adopt prescribed biotech traits that are deemed essential adaptation measures', rather than supporting documented local initiatives based on adaptive practices, largely by women (ibid.). This is closely related to geoengineering concerns, as geoengineering is a form of adaptation. If researchers were able to genetically engineer crops with increased leaf reflectivity, for instance, as a form of geoengineering, it is conceivable that such traits may become governed by intellectual property laws and owned by corporations — perhaps even to be forced upon farmers. Consider the precedent of the 1935/1936 Soil Conservation Acts in the USA, in which farmers were given incentives to grow soil-building crops to help combat the devastating Dust Bowl (Roosevelt, 1936). Given that drought-resistant seeds are already a first response for many Western policy makers when it comes to dealing with climatic stress, it is possible that governments would incentivize planting of patented crops with climate-friendly traits.

CONCLUSION: GEOENGINEERING NOT FOR THE PEOPLE, BUT FROM THE PEOPLE?

Both capital-driven and humanitarian-driven approaches to geoengineering have their problems. Yet should geoengineering be required to alleviate suffering as a result of damage already caused due to inertia in the climate system, how should it be approached? Is it possible to imagine geoengineering being driven by a desire for social change, as a means to transform society? This does not place geoengineering in the box of 'environmental issues', but acknowledges that geoengineering is coupled to complex social, cultural and economic systems (Allenby, 2010). Rather than being about 'the environment' or 'climate change', the geoengineering described here is about restructuring socio-ecological systems to improve energy access, land tenure and food security. This article concludes by considering the two challenges posed by such collective climate remediation, namely scale and participation.

The challenge of scale is central to the implementation of participatory and socially transformative projects. Geoengineering implies control at a grand scale, and there is a danger that it could be implemented by an elite few, without democratic consultation. In the face of the unspoken assumption that it will be easier to change the climate under the direction of the few, we may forget to ask whether geoengineering could also be undertaken by the many. Is it possible to imagine a participatory, local approach to climate remediation? Such an approach might be less politically problematic, and could open up new technical possibilities.

The Challenge of Scale: A Territorial Approach to Climate Remediation

Humphreys addresses the question of scale and draws a helpful distinction between commons-based and territorial geoengineering. Territorial techniques (like desert reflectors, mineral sequestration, artificial trees and afforestation) are applied in specific territories, while techniques like ocean fertilization, cloud whitening and stratospheric aerosols operate in the global commons (Humphreys, 2011: 105). Many of the territorial techniques would need the active support of local authorities and communities if they were to be successful. According to Humphreys (ibid.), 'The form of governance required would be both decentralized and participatory, yet also regulatory, with states reporting on the implementation of any commitments internationally'.

One possibility for creating such a collaborative project is to begin by observing rural territorial dynamics, without directly involving the state, and then, using multilateral funds, implement projects suited to that ecological and cultural terrain. Consider the problem of charcoal burning in Somalia — a region which is only nominally a state. No progress is going to be made by

transferring funds to the ineffectual 'government' to implement afforestation or transition from charcoal production to biochar. Rather, local projects would have to work with clan-based or regional actors, taking into account the fact that charcoal is one of Somalia's key exports. Community-based geoengineering projects could strengthen local institutions, address land tenure conflicts and insecurity, and repair food systems. Any territorial sequestration system would have to be well integrated with both agricultural and energy policy: these flows of carbon and nitrogen can no longer be regarded as separate systems.

The problem of scale is not unique to geoengineering. Žižek (2009: 84) writes that in order to approach the energy, food and water crises, 'it will be necessary to invent new forms of large-scale collective action; neither the standard forms of state intervention nor the much-praised forms of local self-organization will be up to the job'. All major problems have this element: local projects are restricted by limited resources and application, but large state or multilateral projects often languish under bureaucracy, corruption and a poor understanding of local territorial dynamics. Development aid also faces large-scale inefficiencies, although solutions like microfinance or cash transfers are addressing the scale challenge in innovative ways. Vandemoortele (2011) holds that we need an approach to development that is not donor-centric; perhaps the same is true for geoengineering. We are so focused on what large organizations can give to 'the people' that we lose sight of what the people need, want and, most importantly, can do for themselves. Large-scale does not necessarily imply top-down management.

The Challenge of Participation: A Visionary Approach to Climate Remediation

If humans are capable of large-scale collective action involving many disciplines, why have we not mitigated emissions by now? Why do we consider collective participation in geoengineering, when it would obviously be better to collectively participate in not emitting greenhouse gases? A number of points arise here. First, like most other researchers, I regard geoengineering as a 'Plan B', to be considered only in the event that mitigation does not restore the climate to one which can support diverse species of life. Second, until recently, we have not had the media and communication technologies that could help coordinate large-scale collective action. Third, part of the failure to mitigate emissions could be attributed to an environmentalism that lacks vision; perhaps we have more chance of initiating action around a creative project rather than calling for action based on sacrifice, guilt, blame or limits. Environmentalism is suffering from other afflictions beyond corporate lobbies: we might think of the concept 'environment' itself, the postmodern lack of faith in grand narratives, the resentment it has elicited from the Right. As Chaloupka (2008: 240) writes, 'environmentalism is both a leading harbinger of modernism's exhaustion and a victim of corrosive

resentment'. These conceptual and philosophical weaknesses contribute to the lack of a compelling vision. Shellenberger and Nordhaus (2004: 31) observe that Martin Luther King, Jr.'s 'I have a dream speech' is famous 'because it put forward an inspiring, positive vision that carried a critique of the current moment within it'. They challenge us to imagine an alternative, 'I have a nightmare' speech, and argue that 'a positive, transformative vision doesn't just inspire, it also creates the cognitive space for assumptions to be challenged and new ideas to surface' (ibid.).

Participatory, regionally-based carbon sequestration — or transformative geoengineering, or mega-gardening or climate remediation — would at least offer a sense of vision. It would steer clear of the pitfalls of a grand narrative, as it would manifest differently in different cultures and ecosystems; it might emerge as peridotite carbonation in Oman or Papua New Guinea, afforestation on degraded lands, cloud albedo modification in the northeast Pacific, or increased leaf reflectivity in central North America and mid-latitude Eurasia. These visions could easily be dystopian or utopian, depending on how they are executed, and the rationale that informs them. Can global social media help bring these tailored visions together? What other cultural, aesthetic, scientific, economic and political actions are needed to enable such a vision? These questions may seem premature, but it would be to the advantage of development scholars to begin thinking about them now. If we do not start voicing our views on how the research and deployment of these technologies should develop, we may be in for unpleasant surprises further along the road. A first step could be to ensure geoengineering technologies are assessed not just on the merits of costs versus benefits, effectiveness and risks, but also within a socio-ecological framework, according to their co-benefits and potential for transformative change. There is much interdisciplinary work to be carried out in this field, and the time is ripe for undertaking it.

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