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ROAD TO "PLAN B", FIRST STOP - REGULATION: INTERNATIONAL AND DOMESTIC REGULATION OF SOLAR GEOENGINEERING

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Abstract

Anthropogenic climate change is arguably the most pressing challenge facing the Earth and humankind. Attempts to reduce greenhouse gas emissions have been dismal thus far, prompting researchers to look elsewhere to limit warming. The radical geoengineering method of stratospheric aerosol injection (SAI) is widely debated; however, increasingly considered a legitimate means to limit warming. This paper examines the current state of international law, highlighting the lacuna that leaves regulation to domestic legal systems. Therefore, this paper evaluates Aotearoa's law to determine its capacity to regulate SAI effectively. Given the transboundary nature of SAI, this paper proposes that Aotearoa take an anticipatory approach to constrain its potential use before an international consensus is met. This paper does not intend to rule out SAI as a means of limiting warming. The paper instead argues that specific considerations require the protection of stricter regulation until SAI can be legitimately considered alongside mitigation and adaptation.

Subjects and Topics

Geoengineering – Solar Radiation Management - International Law – Climate Change Law

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I Introduction

Anthropogenic climate change is one of the most prominent issues facing the Earth today – and its impacts cannot be overstated. The world's reliance on burning fossil fuels since the industrial revolution has caused a build-up of greenhouse gases in the atmosphere, causing warming.[1] A plethora of human-induced weather and climate extremes are affecting every region globally, with some areas and people noticeably more vulnerable to its impacts.[2] Groups particularly vulnerable to the effects of anthropogenic climate change include Māori, Aotearoa's indigenous peoples, who hold a unique relationship with the environment.[3]

Future impacts of climate change can be alleviated through effective adaptation and mitigation.[4] However, efforts have been largely unsuccessful thus far.[5] Sooner rather than later, the international community will need to confront the "uncomfortable reality"[6] that warming is not abating, despite efforts to limit global average temperatures below 1.5-2°C above pre-industrial levels.[7] As the situation rapidly worsens for countries across the globe, radical methods to combat warming have been proposed.

Geoengineering, commonly referred to as the "Plan B" for climate change, is a subject of much debate. Often criticised as the act of "playing God",[8] geoengineering is the deliberate large-scale intervention in the Earth's climate system to mitigate global warming and climate change.[9] Geoengineering methods include both Carbon Dioxide Removal (CDR) and Solar Radiation Management (SRM) techniques. SRM methods seek to counteract global warming associated with climate change by deliberately controlling the Earth's solar energy balance.[10]

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[1] IPCC "Summary for Policymakers" in Valerie Masson-Delmotte and others (eds) in *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, 2021) at [A.1.1].
[2] IPCC *Climate Change 2014: Impacts, Adaptation, Vulnerability. Part B: Regional Aspects. Contribution of the Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (2014) at 1619.
[3] Kristen Wang and others "The Implications of Climate Change on Indigenous People" (2021) 1(3) Across the Spectrum of Socioeconomics 58 at 71.
[4] However, some climate impacts are already irreversible due to past and future emissions, see IPCC "Summary for Policymakers", above n 1, at [B.5].
[5] See IPCC "Summary for Policymakers", above n 1, at [B.1].
[6] Janos Pasztor "The Need for Governance of Climate Geoengineering" (2017) 31(4) Ethics & International Affairs 419 at 419.
[7] See United Nations Environment Programme *Emissions Gap Report 2020* UN Doc DEW/2310/NA (9 December 2020) at xiv.
[8] Leslie Paul Thiele "Geoengineering and sustainability (2019) 28(3) Environmental Politics 460 at 463.
[9] The Royal Society *Geoengineering the Climate: Science Governance and Uncertainty* (2009).
[10] Kerryn Brent, Jeffrey McGee and Amy Maguire "Does the 'No-Harm' Rule Have a Role in Preventing Transboundary Harm and Harm to the Global Atmospheric Commons from Geoengineering?" (2015) 5(2-3) Climate Law 35 at 36-37.

One widely debated method of SRM is Stratospheric Aerosol Injection (SAI) – a conceptual proposal to utilise the albedo effect by injecting large quantities of gas into the stratosphere.[11] SAI is the most-researched method of SRM, with a widespread consensus that the technique could effectively limit warming to below 1.5°C.[12] By reducing warming, SAI could reduce a number of associated implications, including the rate of sea-level rise, sea-ice loss and frequency of extreme storms.[13] However, SAI poses serious risks, including precipitation changes, depleting ozone concentrations and potentially reducing biodiversity.[14] The adverse side effects, ethical concerns and potential impacts on sustainable development connected to SAI have impeded its research, development, governance and regulation.[15]

The capacity for international instruments to regulate SAI is far from crystal clear. However, it appears unfit for this purpose. Several international instruments apply to SAI activities, including the 1992 Convention on Biological Diversity (the CBD),[16] the 1976 Convention on the Prohibition of Military or any Hostile Use of Environmental Modification Techniques (ENMOD Convention)[17] and the 1985 Vienna Convention for the Protection of the Ozone Layer (Vienna Convention).[18] However, the application of these instruments and applicability and efficacy as an adequate regulatory regime is questioned.

Additionally, states that pose risks of significant harm to transboundary areas or global commons are subject to the principles and customs of international environmental law.[19] Among such include the no-harm rule and the precautionary principle. The no-harm rule is binding on states as customary international law.[20] The rule imposes a duty on states to prevent or minimise significant transboundary harms to the territory of other states or global

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[11] Heleen de Coninck and others "Strengthening and Implementing the Global Response" in Valerie Masson-Delmotte and others (eds) *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (IPCC, 2018) 313 at 348.
[12] At 350.
[13] At 347.
[14] At 347.
[15] At 317.
[16] United Nations Convention on Biological Diversity 1760 UNTS 79 (opened for signature 5 June 1992, entered into force 29 December 1993). [UNCBD].
[17] United Nations Convention on the Prohibition of Military or any Hostile Use of Environmental Modification Techniques (opened for signature 18 May 1977, entered into force 5 October 1978). [ENMOD].
[18] Vienna Convention for the Protection of the Ozone Layer 1513 UNTS 293 (opened for signature 22 March 1985, entered into force 22 September 1988). [Vienna Convention].
[19] Karen N Scott "International Law in the Anthropocene: Responding to the Geoengineering Challenge" (2013) 34 Michigan Journal of International Law 309 at 313.
[20] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 37.

commons.[21] The precautionary principle is a legal tool[22] intended to manage risks and uncertainties, often employed when confronting emerging technologies.[23] The capacity for the no-harm rule and precautionary principle to regulate SAI activities is a matter of debate.[24] In light of the international regulatory lacuna on SAI (that may remain this way for some time),[25] this paper considers the relevance of domestic laws to the application of SAI. This paper pays due regard to Aotearoa's regulatory regime on high-altitude activities, which may be interpreted as an attempt at providing bottom-up regulation for these emerging technologies.

Part II sets the context by highlighting the current trajectory of anthropogenic climate change. It discusses how the current national pledges under the *Paris Agreement* are inadequate to limit warming to 1.5°C above pre-industrial levels.[26] Part III discusses the different SRM methods of geoengineering, then outlines the implications of SAI specifically to provide background for why SAI should be regulated. Part IV assesses the international law relevant to SAI and concludes that the current state of international law is inadequate to regulate SAI. Part V analyses how SAI is regulated under Aotearoa's domestic law and how such law could be strengthened. Finally, part VI delivers conclusions.

It is hoped that this paper stimulates further discussions into SAI in Aotearoa. This paper is ultimately neutral on whether SAI should be used in future. Nevertheless, this paper argues that further efforts need to be focussed on the regulatory lacuna at present.

II International Context: Climate Change

Geoengineering regulation does not occur in a legal vacuum. Thus, to adequately comprehend and appreciate the legal issues relating to SAI geoengineering regulation, we must outline the extent of the problem. The following discussion contextualises SAI geoengineering within the bounds of anthropogenic climate change. This discussion aims to give a brief overview of the scope of the problem, omitting much of the scientific and technical detail. As part V will be

[21] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 37.
[22] Jesse L Reynolds "International Law: Legal Norms, Principles, Custom, and Organizations" in *The Governance of Solar Geoengineering: Managing Climate Change in the Anthropocene* (Cambridge University Press, 2019) 71 at 77.
[23] At 77.
[24] Karen N Scott, above n 19, at 313.
[25] The inability for UN member States to reach consensus on a draft resolution tabled by Switzerland initiating steps towards geoengineering governance at the fourth UN Environment Assembly is concerning, see United Nations Environment Assembly of the United Nations Environment Programme *Proceedings of the United Nations Environment Assembly at its fourth session* UNEP EA.4/2 (11-15th March 2019) at [84].
[26] Heleen de Coninck and others, above n 11, at 315.

discussing relevant domestic regulation and recommendations for Aotearoa New Zealand, this part will outline specific anthropogenic impacts to Aotearoa. The section concludes by outlining the alarming climate trajectory, which can be highlighted by states' seeming inability to limit warming below the targets of the *Paris Agreement.*

A Climate Change

Only a few would deny the critical state of our globe. The sixth IPCC report states: "the likely range of total human-caused global surface temperature increase from 1850-1900 to 2010-2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C".[27] A myriad of the observed anthropogenic climate change effects since the 1950s is entirely unprecedented.[28] To say increased temperatures are concerning is an understatement. Climate modelling indicates the globe may face irreversible damage if temperatures rise to 1.5ºC above pre-industrial levels.[29]

Climate change is the variability of the Earth's climate system. The temperature of the Earth is affected collaboratively by the incoming energy the Earth absorbs from the sun (warming) and the outgoing energy the Earth emits to space (cooling).[30] The climate system operates in equilibrium when the incoming solar shortwave radiation (SWR) equals outgoing radiation.[31]

Greenhouse gases have a powerful effect on warming the climate[32] by trapping thermal radiation in the atmosphere.[33] While this effect is natural, and without it, the Earth's temperature would be well below freezing, rapid increases in greenhouse gas emissions have thrown the equilibrium out of balance, trapping additional heat and creating dangerous levels of warming.[34]

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[27] IPCC "Summary for Policymakers", above n 1, at [A.1.3].
[28] At [A.1.4].
[29] Timothy M Lenton and others "Climate Tipping Points – Too Risky to Bet Against" (2019) 575 Nature 592 at 592.
[30] Julia Rosen "The Science of Climate Change Explained: Facts, Evidence and Proof" (19 April 2021) NY Times <www.nytimes.com>.
[31] Saadia Radcliffe "Geoengineering: Ocean Iron Fertilisation and the Law of the Sea" (LLB (Masters) Research Paper, Victoria University of Wellington, 2014) at 8.
[32] IPCC "Summary for Policymakers", above n 1, at [A.1.3]; The Royal Society, above n 9, at 2.
[33] Kurzgesagt – In a Nutshell "Geoengineering: A Horrible Idea We Might Have to Do" (8 October 2020) YouTube <www.youtube.com>.
[34] Rebecca Lindsey "Climate Change: Atmospheric Carbon Dioxide" (14 August 2020) Climate.gov <www.climate.gov>.

The atmospheric concentration of carbon dioxide has rapidly increased since the beginning of the Industrial Revolution in 1750[35] through a combination of fossil fuel (coal, oil and gas) extraction and combustion and deforestation.[36] Climate models indicate that virtually all temperature increases since 1950 are directly attributable to emissions from human activities.[37]

The consequences of climate change are planetary in scope.[38] Devastating impacts of climate change include warmer global temperatures, rising sea levels, melting of ice in the Antarctic and the Arctic, ocean acidification and more frequent extreme weather events.[39]

Climate change raises security concerns,[40] endangering human settlement,[41] water and food security, energy supply and economic stability all over the globe.[42] The intensification of populations in desirable land areas will increase, as people will be forced to migrate from uninhabitable land areas.[43] These consequences pose security threats on people, with the increased pressure and competition for depleting resources.[44] Climate change will inevitably "exacerbate humanitarian crises, promote state failures and borer disputes, and produce more conventional threats to national and international security".[45]

More frequent extreme weather events will increase death tolls[46] and climate loss and damage – effects of which fall disproportionately on vulnerable developing countries that have historically contributed least to global greenhouse emissions.[47] Climate change raises questions of equitable cost-sharing – as wealthier countries have vastly better economic and technological capacity to adapt to the impacts of climate change.[48]

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[35] IPCC "Summary for Policymakers", above n 1, at [A.1.1].
[36] Saadia Radcliffe, above n 31, at 8.
[37] IPCC "Summary for Policymakers", above n 1, at 8.
[38] Jutta Brunnée "The Rule of International (Environmental) Law and Complex Problems" in Heike Krieger, Georg Nolte and Andreas Zimmermann (eds) *The International Rule of Law: Rise or Decline?* (Oxford University Press, Oxford, 2019) 211 at 215.
[39] IPCC "Summary for Policymakers", above n 1, at [A.3]; Karen N Scott, above n 19, at 314.
[40] IPCC *Climate Change 2014: Synthesis Report. Contribution of Working Groups, I, II and III to the Fifth Assessment Report of Intergovernmental Panel on Climate Change* (2014) at vii.
[41] Jutta Brunnée, above n 38, at 215.
[42] At 215.
[43] Saadia Radcliffe, above n 31, at 10.
[44] IPCC *Climate Change 2014: Synthesis Report,* above n 40, at 13.
[45] Jutta Brunnée, above n 38, at 216.
[46] IPCC *Climate Change 2014: Synthesis Report,* above n 42, at 69.
[47] *A Literature Review on the Topics in the Context of Thematic Area 2 of the Work Programme on Loss and Damage: A Range of Approaches to Address Loss and Damage Associated with the Adverse Effects of Climate Change* FCCC/SB1/2012/INF.14 (15 November 2012) at 5.
[48] Jutta Brunnée, above n 38, at 216.

Many consequences of climate change are already occurring and are irreversible due to past, present and future emissions.[49] Climate change is an intergenerational issue.[50] By continuing business-as-usual, humans "are in the process of driving what has been described as the Sixth Extinction".[51]

1 Aotearoa and Climate Change

Anthropogenic climate change is already having drastic impacts on Aotearoa. Such effects will inevitably burden Aotearoa's future generations.[52] National average temperatures have increased by 1.13°C between 1909 to 2019.[53] Anthropogenic induced flooding and droughts cost Aotearoa $840 million in insured damages and economic losses alone between 2007 and 2017.[54] These effects will only continue to worsen. Like most regions worldwide, profound changes to Aotearoa's climate are anticipated, inducing the risks of extreme weather events such as droughts, wildfires and rainfall.[55]

(a) Vulnerability of indigenous groups to climate change

Māori peoples are the indigenous peoples of Aotearoa. Māori are amongst the groups most vulnerable to the impacts of climate change. Māori health is heavily linked to the health of their environment.[56] Anthropogenic climate impacts have profoundly impacted tangata whenua (the people of the land), contributing to deteriorated physical and mental health outcomes.[57] Māori social, economic and cultural systems rely heavily on the natural environment.[58] For instance, as of 2014, approximately 50 per cent "of the total Māori asset base is invested in "climate-sensitive" primary industries (forestry, agriculture, fishing and tourism)".[59] Thus, a large proportion of Māori business economy is in a vulnerable position – highly susceptible to the implications of anthropogenic climate change.

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[49] IPCC "Summary for Policymakers", above n 1, at [B.5].
[50] Jutta Brunnée, above n 38, at 215.
[51] Karen N Scott, above n 19, at 315.
[52] Ministry for the Environment and Stats NZ *Our atmosphere and climate 2020: Summary* (New Zealand's Environmental Reporting Series, 2020) at 3.
[53] At 3.
[54] At 4.
[55] At 4.
[56] Kristen Wang and others, above n 3, at 71.
[57] At 71.
[58] Climate Change Technology Transfer Programme *The climate change challenge for Māori* (Ministry for Primary Industries, June 2014) at 1.
[59] At 1.

(b) Indigenous relationship with nature

Māori conceptions of health and wellbeing extend beyond mere physical interpretations, taking a more holistic approach.[60] The United Nations Development Group, 'Guidelines on Indigenous Peoples' Issues' states: "a healthy indigenous community is one in which the community as a whole enjoys harmonious relations with its environment".[61] Jones and others state:[62]

> As with other indigenous peoples, the loss of identity due to displacement and dispossession of lands, resources and waters (likely to occur with climate change) is intimately linked to adverse physical and mental health outcomes.

However, these losses go further than economic implications as "climate change threatens the loss of culturally significant land, taonga species and resources affecting the perpetuity of mātauranga and tikanga Māori".[63] Māori groups, including Whānau, Hāpu, Iwi and communities, hold a unique relationship with the natural environment.[64] Te-Wainuiarua Poa sheds light on this connection:[65]

> For Māori, self-identity and group identity are intimately connected to the environment and the experiences our ancestors cultivated through the land. Mātauranga Māori is a body of knowledge encapsulating these specific life experiences that form the basis of our identity, language, cultural practices and value systems. Much like other indigenous knowledge systems, mātauranga Māori draws from and reinforces the holistic connection that Māori have to the land and sea. It embodies our inherent connections to the ecosystem, spiritual beings and other living species we share the land and sea with.

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[60] Rhys Jones, Hayley Bennett, Gay Keating and Alison Blaiklock "Climate Change and the Right to Health for Māori in Aotearoa/New Zealand" (2014) 16(1) Health and Human Rights Journal.
[61] United Nations Development Group *Guidelines on Indigenous Peoples' Issues* UN Doc HR/P/PT/16 (2009) at 21.
[62] Rhys Jones, Hayley Bennett, Gay Keating and Alison Blaiklock, above n 60.
[63] "Why climate change matters to Māori" (2020) Science Learning Hub <www.sciencelearn.org.nz>.
[64] Climate Change Technology Transfer Programme, above n 58, at 1.
[65] Te-Wainuiarua Poa "Mātauranga Māori: Applying a Māori lens to environmental management" (1 February 2020) Environmental Protection Authority: Te Mana Rauhī Taiao <www.epa.govt.nz>.

Climate change threatens mātauranga, the ability to pass on customary practices tied to traditional resources and taonga and will significantly weaken the practice of manaakitanga (hospitality and generosity).[66]

Against this background, the relationship between Māori and the environment must be considered in climate-related regulation – both in the context of Aotearoa and at the global level. These issues will be touched on again in part V of this paper.

B A troubling trajectory despite the Paris Agreement

In 2015, the *Paris Agreement* - what can be considered as the international community's long-term commitment to collectively addressing and combating climate change[67] - was negotiated by states.[68] The *Agreement* "aims to limit global mean temperature increase to well below 2°C above pre-industrial levels and pursue efforts to limit temperature increase to 1.5°C".[69] The bottom-up approach of the *Agreement* allows countries to determine their own emission reductions (Nationally Determined Contributions - NDCs),[70] which incrementally become more ambitious.[71]

The *Agreement* was, as Burns and Craik state, "hailed as a momentous achievement in the titanic struggle to avert potentially catastrophic climate change during this century and beyond".[72] Admittedly, the *Agreement* was somewhat monumental in gaining such widespread participation from states, with some of the world's leading emitters ratifying the agreement. However, despite the increased palatability for states, which seldom bind themselves to enforceable commitments, the *Agreement* is perhaps more bark than bite. Whether member states have the political willpower to achieve the *Agreement's* objectives of limiting climatic temperatures to well below 2°C or aspiring not to exceed 1.5°C is unlikely.[73]

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[66] Ministry for the Environment and Stats NZ *Our atmosphere and climate 2020* (New Zealand's Environmental Reporting Series, 1523, 2020) at 55.
[67] Will Burns and Neil Craik "The Paris Agreement and Climate Geoengineering" (paper presented to First Annual Research Roundtable on Global Climate Change Governance: Geoengineering, Northwestern University School of Law, 17 April 2017) at 1.
[68] Paris Agreement (adopted 12 December 2015; entered into force 4 November 2016).
[69] Kerryn Brent, Jan McDonald, Jeffrey McGee and Brendan Gogarty "Carbon Dioxide Removal Geoengineering" (2018) 92 ALJ 830 at 830.
[70] William Hare and others "The Architecture of the Global Climate Regime: a Top-down Perspective" (2011) 10 Climate Policy 600 at 601.
[71] Paris Agreement, above n 68, art 4.
[72] Will Burns and Neil Craik, above n 67, at 1.
[73] At 1.

To date, international trends are discouraging.[74] Concerns regarding the trajectory of climate change were confirmed in 2020 when the United Nations Environment Programme (UNEP) determined whether the international community was "on track to bridging the gap"[75] of limiting global temperature warming below 2°C. Their answer, "absolutely not,"[76] as a total commitment to current NDCs "will limit global warming to no less than 3.2°C by the end of the century".[77] Limiting average global warming to 1.5°C above pre-industrial levels would require radical emissions reductions and transformative change globally.[78]

Aotearoa was amongst the first countries to commit to the *Agreement,* largely supporting action to combat the significant risks Pacific Island neighbouring nations face.[79] Nevertheless, the current climatic trajectory is alarming. The Intergovernmental Panel on Climate Change (IPCC) has confirmed the worst nightmares for some, stating "some island nations are *likely* to become uninhabitable due to climate-related ocean and cryosphere change"[80] as sea-level rise will likely cause small island nations to become submerged.

Without introducing more radically ambitious emissions reductions and adaptation efforts and creating "transformative systemic change",[81] our current global warming trajectory will cause devastating consequences for human institutions and ecosystems.[82] At a 3.0°C increase in global average temperatures, the Greenland Ice Sheet could completely disappear over the next 1000 years – increasing sea levels by 7 metres.[83] At a 3.0°C increase in global average temperatures, virtually all coral reefs, home to approximately one-third of the entire marine species, would be lost.[84] At a 3-4.0°C increase in global average temperatures, 60% of the Earth's species could be threatened with extinction.[85]

With bleak climate projections, international leaders may soon be forced to explore more radical climate change policy options to help prevent the globe from crossing critical

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[74] United Nations Environment Programme, above n 7, at xiv.
[75] At xiv.
[76] At xiv.
[77] IISD "Emissions Gap Report 2020: 1.5°C Goal Requires Green Recovery, Rapid Action" (16 December 2020) IISD SDG Knowledge Hub <www.sdg.iisd.org>.
[78] Heleen de Coninck and others, above n 11, at 315.
[79] See "NZ boosts support for climate action across the Pacific" (press release, 15 August 2019).
[80] IPCC "Summary for Policymakers" in Hans-Otto Pörtner and others (eds) *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* (In Press, 2019) at 27.
[81] Heleen de Coninck and others, above n 11, at 315.
[82] Will Burns and Neil Craik, above n 67, at 1.
[83] At 1.
[84] At 1.
[85] At 1.

thresholds. Perhaps ironically, and most certainly symbolically of the Anthropocene, is the proposed method of geoengineering[86] which will be discussed in the following part.

III Geoengineering – Plan B?

The Earth's climatic challenges could theoretically be resolved by states collectively by radically abating the release of greenhouse gases. In an ideal world, political will could achieve this. Instead, this is a complex world, with complex issues requiring complex solutions. As discussed in the last part, collective mitigation efforts to abate growing greenhouse gas emissions have been dismal thus far, lacking any real, meaningful change.[87]

Next to mitigation, the other conventional approach to tackling climate change is adaptation – which is briefly defined as "actions aimed at reducing the vulnerability to dangerous climate change effects".[88] However, adaptation measures are incredibly costly, which has raised intricate debates around equitable cost-sharing.[89] It is against the backdrop of the globe's perceived climatic failure and seeming inability for the climate regime to tackle global warming that geoengineering has entered the limelight.[90] This part explains what geoengineering is, focusing on SAI, an SRM method of geoengineering.

A Geoengineering Explained

Definitions of geoengineering (also referred to as climate engineering) vary. It is most commonly defined as "the intentional large-scale manipulation of the environment…intended to reduce undesired anthropogenic climate change".[91] The IPCC has previously framed geoengineering to encompass "a broad set of methods and technologies that aim to deliberately alter the climate system in order to alleviate the impacts of climate change".[92] The term

[86] Karen N Scott, above n 19, at 318.
[87] Saadia Radcliffe, above n 31, at 11.
[88] Bert Gordijn and Henk ten Have "Ethics of mitigation, adaptation and geoengineering" (2012) 15 Med Health Care and Philos 1 at 1.
[89] At 2.
[90] At 1.
[91] David W Keith "Geoengineering the Climate: History and Prospect" (2000) 25 Annu Rev Energy Environ 245 at 245.
[92] IPCC *Meeting Report of the Intergovernmental Panel on Climate Change Expert Meeting on Geoengineering* (2012) at 2.

'geoengineering' rather broadly captures "a variety of divergent technologies that are in most cases still technologically immature".[93]

Though it was considered "still in an embryonic stage of technological development" in the last decade,[94] geoengineering is increasingly being seriously debated as a means of tackling anthropogenic climate change. The attraction primarily lies in the straightforward and somewhat convenient nature of this method – as geoengineering does not require or involve shifting towards the seemingly unpalatable sustainable patterns of behaviour that are commonly associated with emissions reductions or adaptation methods.[95]

Proponents of further research and development (and potentially future deployment) of geoengineering claim the method may be necessary if efforts to mitigate emissions do not rapidly improve.[96] However, even when emissions reductions are radically improved, the likelihood that specific climate tipping points have already been crossed is high.[97] It is no surprise that humans have begun to develop ways to manipulate the environment to achieve the desired ends. However, despite the desirability of its perceived convenience, the possibility of actually deploying geoengineering methods to counteract anthropogenic climate change is, unsurprisingly, hugely controversial.[98]

Currently, geoengineering is typically classed in one of two categories of intervention: one, carbon dioxide removal (CDR); the other, solar radiation management (SRM).[99] CDR methods intend to "increase net carbon sinks from the atmosphere at a scale sufficiently large to alter climate".[100] SRM methods seek to "reduce the amount of absorbed solar energy in the climate system".[101] Both CDR and SRM technologies remain in their infancy.[102] Geoengineering is distinguished from weather modification and ecological engineering. However, the IPCC state that the boundary can be blurry.[103]

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[93] Bert Gordijn and Henk ten Have, above n 88, at 2.
[94] At 1.
[95] Karen N Scott, above n 19, at 320.
[96] Bert Gordijn and Henk ten Have, above n 88, at 2.
[97] At 2; Damian Carrington "Climate emergency: world 'may have crossed tipping points' (27 November 2019) The Guardian <www.theguardian.com>.
[98] David W Keith, above n 91, at 245.
[99] Janos Pasztor, above n 6, at 420.
[100] Ottmar Edenhofer and others (eds) *IPCC Expert Meeting on Geoengineering* (IPCC, Meeting Report, June 2011) at 2.
[101] At 2.
[102] Janos Pasztor, above n 6, at 420.
[103] Ottmar Edenhofer and others (eds), above n 100, at 2.

B Carbon Dioxide Removal

CDR processes essentially offset existing greenhouse gas emissions by removing and storing carbon dioxide from the Earth's atmosphere.[104] CDR involves reducing "atmospheric concentrations of greenhouse gases through the enhancement or manipulation of natural or artificial carbon sinks, including the oceans and the terrestrial biosphere".[105] Technologies and methods for CDR and storage are wide-ranging, referring to terrestrial and marine-based proposals,[106] which include:[107]

> afforestation and reforestation; enhanced mineral weathering (removing CO2 from the atmosphere through chemical reactions with carbonate and silicate rocks); and direct air capture of CO2 using chemical "scrubbing" processes.

CDR technologies were considered essential for limiting warming below the 2 degrees limit in most modelling scenarios of the IPCC Fifth Assessment Report.[108] The report, which influenced the *Paris Agreement* temperature ranges, referred to these as negative emissions technologies. All modelling scenarios to limit warming below 1.5°C assume the use of large-scale negative emissions after 2050.[109]

Despite its growing prominence in international climate change policy, the issue with relying on these forms of technology is quite apparent. No CDR technique is near ready for deployment at the required scale, nor price feasibility, to limiting warming below the *Paris Agreement* temperature ranges.[110]

CDR is not a straightforward method for bringing global emissions down. There are many risks associated with CDR techniques. Take Janos Pasztor's example of the implications related to solely relying on bioenergy with carbon capture and storage (BECCS) to bring global greenhouse emissions to net-zero:[111]

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[104] Heleen de Coninck and others, above n 11, at 342.
[105] Karen N Scott, above n 19, at 321.
[106] Kerryn Brent, Jan McDonald, Jeffrey McGee and Brendan Gogarty, above n 69, at 831.
[107] At 831.
[108] IPCC *Climate Change 2014: Synthesis Report,* above n 40, at 89; Janos Pasztor, above n 6, at 420.
[109] Kerryn Brent, Jan McDonald, Jeffrey McGee and Brendan Gogarty, above n 69, at 831.
[110] Janos Pasztor, above n 6, at 420.
[111] At 423.

> [this] would require planting a land area potentially one to two times the size of India. Land of that size devoted to energy crops – up to a quarter of global agricultural land, wherever it may be – would put severe pressures on global food production and would greatly affect biodiversity. It would also require enormous amounts of water, [fertiliser], and pesticide.

This paper will be leaving CDR to the side and focussing primarily on SRM geoengineering techniques.

C Solar Radiation Management

Solar radiation management (SRM) is defined as the "intentional modification of the Earth's short-wave radiation budget with the aim of reducing warming".[112] Unlike CDR, SRM measures are unrelated to greenhouse gas levels.[113] Instead, SRM aims to cool the Earth's surface temperature through albedo enhancement[114] - preventing the Earth from absorbing as much solar radiation.[115] SRM techniques either deflect solar radiation back into space before it reaches Earth or reflects radiation by making the Earth's surface and atmosphere more reflective.[116] This technique cools the Earth by balancing the sun's incoming radiation - "mainly short-wave ultraviolet and visible light"[117] – that heats the Earth against levels of out-going (long-wave) thermal infrared radiation, which cools it.[118]

SRM strategies are broadly based on the albedo effect[119] to deflect incoming radiation. SRM techniques include enhancing urban albedo,[120] marine cloud brightening and artificial injection of stratospheric aerosols.[121] This paper will focus predominantly on the method of SAI, which is most commonly cited as the method which poses the greatest prospect for limiting warming.[122]

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112 Ottmar Edenhofer and others (eds), above n 100, at 2.
113 Heleen de Coninck and others, above n 11, at 349.
114 Karen N Scott, above n 19, at 321.
115 The Royal Society, above n 9, at 1.
116 At 1.
117 At 2.
118 At 2.
119 Janos Pasztor, above n 6, at 421.
120 Karen N Scott, above n 19, at 326.
121 Ottmar Edenhofer and others (eds), above n 100, at 2.
122 Timothy M Lenton and Naomi E Vaughan "The radiative forcing potential of different climate geoengineering options" (2009) 9 Atmos Chem Phys 5539 at 5556; Naomi E Vaughan and Timothy M Lenton "A review of climate geoengineering proposals" (2011) 109 Climatic Change 745 at 773.

D Why this paper focusses on SRM and SAI – distinctions explained

While both CDR and SRM methods fit within the broader definition of 'geoengineering', it is not difficult to gather the inherent differences between the techniques. The methods sit on a sliding scale in many regards, particularly with the extent to which they have been researched, tested, deployed and faced public and ethical scrutiny. The differences between the two methods can be exemplified by IPCC efforts to distinguish between the two. In the IPCC report, "Global Warming of 1.5°C", the term "geoengineering" was omitted. Instead, the IPCC classify CDR and SRM technologies as response options to limit global warming to 1.5°C or below 2°C.[123]

CDR aims to combat warming by reducing carbon dioxide that accumulates in the air through emissions and thus is well interlinked with conventional methods of emissions reductions.[124] To some extent, CDR techniques "can be applied as an additional measure alongside mitigation and adaptation".[125] Some scholars argue that CDR techniques should not be included within the definition of geoengineering.[126] CDR methods are more palatable and less controversial than SRM methods. Many countries have adopted the CDR method of afforestation and the implementation of large-scale forest projects.[127] Article 5 of the *Paris Agreement* expressly recognises that states *should* direct efforts towards conserving and enhancing forest sinks to reduce greenhouse gases.[128]

Admittedly, CDR and SRM indeed share some critical features that cannot be understated. Both methods are remedies of anthropogenic climate change, compared to mitigation methods that directly reduce greenhouse gas emissions to prevent climate change and target the crux of the issue.[129] Because CDR and SRM are remedies, "both are likely to weaken [the drive] for emissions reduction and pose ethical risks".[130] For these reasons, CDR must remain *within* the definition of geoengineering. However, isolating the focus of this paper to SAI is warranted –

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123 Myles R Allen and others "Framing and Context" in Valerie Masson-Delmotte and others (eds) *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (IPCC, 2018) 49 at 70.
124 Ying Chen "International Debate Over Geoengineering and Geoengineering Governance" (2017) 5(3) Chinese Journal of Urban and Environmental Studies 1 at 2.
125 At 4.
126 At 3.
127 At 2.
128 Paris Agreement, above n 68, art 5(1).
129 Ying Chen, above n 124, at 3.
130 At 3.

with climate modelling indicating SAI has the highest potential for success,[131] yet the risks imposed are perhaps the gravest.

E Stratospheric Aerosol Injection

The theoretical concept of Stratospheric Aerosol Injection (SAI) has gained traction and is the subject of much debate. The method involves spraying or injecting aerosols of sulphuric gas or other particles into the stratosphere – dispersing a fine layer of particles in the stratosphere to reflect solar radiation.[132] The method is intended to alter the Earth's energy balance, thereby preventing warming by reflecting incoming solar radiation levels.[133]

The SAI method mimics the natural process of a volcanic eruption.[134] Cooling following volcanic eruptions serves as proof of the effectiveness of sulphate solar radiation – with the global cooling of approximately 0.5°C for a year following the eruption of Mount Pinatubo in 1991.[135] The SAI process does not address the underlying causes of warming and, unlike a volcanic outburst, requires continuous maintenance by regulation injections.[136]

1 Why SAI is so heavily debated

(a) High risk but high reward

SAI is the most widely debated and discussed method of SRM, and there is a large consensus in favour of its efficacy to limit warming below the 1.5°C limits.[137] Climate researchers Lenton and Vaughan have produced detailed examinations comparing the different methods of geoengineering.[138] Lenton and Vaughan concluded that SAI deployment methods (alongside deploying sunshades in space – another SRM technique) carry by far the highest potential success in cooling the climate by 2050.[139] One of the most evident benefits of SAI would be

[131] Timothy M Lenton and Naomi E Vaughan, above n 122; Naomi E Vaughan and Timothy M Lenton "A review of climate geoengineering proposals", above n 122, at 773.
[132] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 37.
[133] At 37.
[134] Janos Pasztor, above n 6, at 421.
[135] National Research Council "15 Solar Radiation Management" in *Advancing the Science of Climate Change* (The National Academies Press, Washington DC, 2010) 377 at 381.
[136] Geoengineering Monitor "Stratospheric Aerosol Injection (Technology Briefing)" (4 February 2021) Geoengineering Monitor <www.geoengineeringmonitor.org>.
[137] Heleen de Coninck and others, above n 11, at 350.
[138] Timothy M Lenton and Naomi E Vaughan, above n 122; Naomi E Vaughan and Timothy M Lenton "A review of climate geoengineering proposals", above n 122.
[139] Timothy M Lenton and Naomi E Vaughan, above n 122; Naomi E Vaughan and Timothy M Lenton "A review of climate geoengineering proposals", above n 122, at 773.

its potential to reduce sea-level rise.[140] Reducing sea-level rise carries widespread benefits for low-lying states, coastlines and maritime environments in preventing forced migration and loss and damage. If SAI could slow the rise in sea levels, this would reduce the risk of "security threats arising from displaced human populations and the loss of defence estate and assets".[141] In contrast, CDR methods would take decades to remove greenhouse gases to the required level.[142]

However, most SRM technologies,[143] including SAI, are not currently deployed beyond the lab.[144] No SRM measures are included within the IPCC's usual definition of mitigation and adaptation.[145] The IPCC assessments increase scientific certainty regarding risks associated with various global warming pathways and possible mitigation and adaptation methods to address them.[146] As the IPCC's mitigation pathways compatible with 1.5°C above preindustrial levels focus on mitigation and adaptation, SRM methods are explicitly excluded.[147] Despite many scientists favouring SAI technology, due to its potential ability to offer a faster, practical and cost-effective way of lowering temperatures,[148] knowledge gaps, uncertainties, risks, and social constraints impede its development.[149]

To date, most knowledge of SAI's effects is based on imperfect model simulations and natural analogues.[150] SAI techniques are the most discussed SRM approach – arguably due to the controversies of this approach and its potential for success.[151] There is a high agreement that deploying large-scale SAI methods would be cost-effective to prevent warming and climate

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[140] Adam Lockyer and Jonathan Symons "The national security implications of solar geoengineering: an Australian perspective" (2019) 73(5) Australian Journal of International Affairs 485 at 493.
[141] Adam Lockyer and Jonathan Symons, above n 140, at 493.
[142] Atiq Rahman "Developing countries must lead on solar geoengineering research" (2018) 556 Nature 22 at 23.
[143] Excluding field testing of marine cloud brightening in Australia see Jeff Tollefson "Can Clouds Save the Great Barrier Reef?" (2021) 596 Nature 476.
[144] Janos Pasztor, above n 6, at 421.
[145] Ottmar Edenhofer and others (eds), above n 100, at 2.
[146] Nicholas Harrison, Janos Pasztor and Kai-Uwe Barani Schmidt "A risk-risk assessment framework for Solar Radiation Modification (International Risk Governance Centre" *EPFL* (online ed, International Risk Governance Centre, 15 July 2021) at 3.
[147] Joeri Rogelj and others "Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development" in Valerie Masson-Delmotte and others (eds) *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (IPCC, 2018) 93 at 98.
[148] Janos Pasztor, above n 6, at 421.
[149] Madelaine Pears "A Plan B for Climate Change? Geoengineering and International Law" (LLB (Masters) Seminar Paper, Victoria University of Wellington, 2021) at 5.
[150] Heleen de Coninck and others, above n 11, at 351.
[151] At 347.

change implications.[152] However, despite its high potential for success, SAI carries the most significant risk.[153] Full SAI deployment would require a lengthy and uninterrupted commitment. The aerosols utilised require constant maintenance and reapplication to maintain SAI's global cooling effects effectively.[154] Aerosol concentration levels would potentially require continued intensification if greenhouse gas levels continue to rise.[155]

The potential risks imposed by sudden termination after such a sustained deployment are troubling. Such a cessation would risk driving rapid catastrophic temperature increases, having detrimental impacts on ecological, social and cultural systems,[156] and "most noticeably biodiversity loss".[157] The severity of such termination has been the subject of much recent debate, and its implications would depend on the degree of cooling.[158] SAI techniques raise ethical issues, firstly as it involves humans meddling with the environment and secondly as it imposes further intergenerational burdens and inequities – condemning future generations to continue these methods.[159]

Even without sudden cessation, the method itself risks endangering societies. Deploying SAI techniques risks further depleting the ozone layer as the particles could potentially trigger chemical reactions causing such an effect.[160] Ozone depletion was an effect observed following the 1991 Mt Pinatubo volcanic eruption.[161] Other concerns include the risk that SAI will impact global climate patterns in negative ways.[162] The decreased quantity and quality of light reaching Earth would have complex and perilous effects on plant life.[163] SAI techniques may affect rainfall and monsoon patterns by altering the global hydrologic cycle, the rate and scale with which rainwater evaporates, condenses, and precipitates.[164] Computer simulations suggest that SAI techniques could risk causing major droughts in Africa and Asia, endangering food and water sources and supplies for two billion people.[165] Some scientists suggest that the

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[152] Heleen de Coninck and others, above n 11, at 348-349.
[153] Timothy M Lenton and Naomi E Vaughan, above n 122, at 5556.
[154] Janos Pasztor, above n 6, at 423.
[155] At 423.
[156] National Research Council, above n 135, at 381.
[157] Heleen de Coninck and others, above n 11, at 351.
[158] At 351.
[159] Janos Pasztor, above n 6, at 423.
[160] Karen N Scott, above n 19, at 328; Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 47.
[161] Subsidiary Body on Scientific, Technical and Technological Advice *Impacts of Climate-Related Geoengineering on Biological Diversity* (UNEP/CBD/SBSTTA/16/INF/28, 5 April 2012) at 46.
[162] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 12, at 47.
[163] Janos Pasztor, above n 6, at 423.
[164] At 423.
[165] Geoengineering Monitor, above n 136.

method may increase surface acid deposition (acid rain) – caused by the aerosol particles eventually falling from the stratosphere into the troposphere.[166]

(b) Ambulance at the bottom of the cliff

Furthermore, SAI methods cannot address or risk potentially even worsening the negative implications from continued ocean acidification.[167] SAI is the ambulance at the bottom of the cliff – only addressing the symptoms of climate change and failing to target the crux of the anthropogenic issue.[168] In other words, SAI geoengineering is a techno-fix, “rather than attacking the problems caused by fossil fuel combustion at their source”.[169] SAI raises the moral hazard risk - by turning to SAI, humans may continue unsustainable practices – deflecting from the underlying problem of human induced climate change. SAI techniques inevitably undermine efforts to reduce emissions and mitigate climate change. Even small-scale research may risk weakening multilateral commitments to emissions reductions.

(c) Transboundary implications

SAI techniques pose potential impacts and risks beyond the deployment territory, as it “is designed to induce change to the atmosphere and global climate system”.[170] Thus changes to the climate system caused by large-scale SAI techniques cannot be contained within boundaries – causing transboundary implications, whether good or bad.

2 Conclusion

For all these reasons outlined, there must be effective regulation in place to safeguard both the environment and people. At this point, this paper argues that due to the transboundary impacts, regulation needs to ensure full-scale SAI methods, and potentially in some instances, even small-scale SAI projects, are not deployed until consensus justifies the risks they pose. The next part assesses the current international regulations that apply to SAI activities to determine their effectiveness, highlighting lacunas and inadequacies.

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[166] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 48.
[167] Heleen de Coninck and others, above n 11, at 351.
[168] Janos Pasztor, above n 6, at 423.
[169] David W Keith, above n 91, at 277.
[170] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 46-47.

IV International Law Regulating SAI – Exposing the Gaps

There exists no comprehensive international framework to govern SAI or any geoengineering measures. Therefore, it is important to consider relevant international legal instruments and principles that may apply to SAI. Aotearoa is subject to the outlined international law, which has helped craft its domestic response to environmental management. The first part assesses the strengths and shortcomings of international instruments, which, although not explicitly created to address SAI, inevitably have some bearing due to the nature of SAI activities. The second part of this section critically evaluates the no-harm rule and the precautionary principle to SAI activities to determine their effectiveness at regulating SAI.

A International Conventions

Several international agreements and conventions may have some bearing on a country's ability to deploy SAI geoengineering as they please. The agreements do not currently regulate or address geoengineering explicitly,[171] therefore, any ability to regulate SAI activities has to be read in.

1 1992 Convention on Biological Diversity (the CBD)[172]

Aotearoa is one of the 196 parties to the CBD.[173] The convention is commonly incorrectly cited for establishing a legally binding moratorium on geoengineering activities.[174] In 2010, a CBD COP decision (decision X/33 paragraph 8(w)) provided "guidance" for countries to consider when determining to undertake or refrain from geoengineering techniques, stating:[175]

> No climate-related [geoengineering] activities that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts, with the exception of small scale scientific research studies that would be conducted in a controlled setting in accordance

[171] Kelsi Bracmort and Richard K Lattanzio *Geoengineering: Governance and Technology Policy* (Congressional Research Service, 26 November 2013) at 31.
[172] UNCBD, above n 16.
[173] "Biodiversity and species conservation" (2021) New Zealand Foreign Affairs & Trade (Manatū Aorere) <www.mfat.govt.nz>.
[174] Karen N Scott, above n 19, at 332.
[175] Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity, decision X/33 (2010) at [8(w)].

> with Article 3 of the Convention, and only if they are justified by the need to gather specific scientific data and are subject to a thorough prior assessment of the potential impacts on the environment.

The decision came mainly in response to ocean iron fertilisation activities. However, footnote to decision X/33 paragraph 8(w) includes SRM technologies within this scope of geoengineering activities.[176] The decision refers to all climate geoengineering activities "that may affect biodiversity"; however, it omits from requiring that such activity must "substantially" affect biodiversity.[177] Furthermore, regarding deployment, guidance around whether an "adequate scientific basis" exists has been omitted – leaving it to be determined by each Party. The same analysis can be made regarding whether an activity is deemed "small scale"[178] and "conducted in a controlled setting".[179] What can be unequivocally extrapolated from the guidance is that a state bears the responsibility to ensure that research conducted within their jurisdiction or control does not cause damage beyond their national territory.[180]

The COP guidance calling for parties to abstain from geoengineering activities is non-binding and, whilst persuasive, cannot hold states to account for acting inconsistently.[181] The language employed merely provides guidance, imposing no legal restrictions to geoengineering research and deployment.[182] There are no specific sanctions against states who undertake research and deployment of SAI geoengineering. The CBD, therefore, does not provide adequate international regulation of SAI geoengineering activities.

Nonetheless, the approach taken by COP is an essentially precautionary approach to geoengineering activities, which may indicate an emerging international norm discouraging geoengineering activities more generally.[183] Ralph Bodle points out that although the COP

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[176] Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity, above n 175, at [8(w)].
[177] Ralph Bodle "Geoengineering and International Law: The Search for Common Legal Ground" (2010) 46(2) Tulsa Law Review 305 at 314.
[178] Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity, above n 175, at [8(w)].
[179] At [8(w)].
[180] UNCBD, above n 16, art 3.
[181] Karen N Scott, above n 19, at 332.
[182] Ralph Bodle, above n 177, at 314.
[183] Natalie Jones "Geoengineering in International law and policy: new challenges for Environmental law" (2013) 3 NZLSJ 113.

decision "is not binding in form or language…it sends a political signal and crystallizes the debate about the conditions that should apply to further geoengineering activities".[184]

In 2012 and later in 2016, decision X/33 paragraph 8(w) was reaffirmed by the COP.[185] Placing a moratorium on SAI activities until scientific certainty is strengthened is entirely justified in light of its potentially devastating effects on biodiversity.

Although the decision of the COP reflects a positive movement towards placing limitations on the use of geoengineering techniques, its legal effect does not appease growing concerns towards the risks of unilateral SAI deployment.

2 1976 Convention on the Prohibition of Military or any Hostile Use of Environmental Modification Techniques (ENMOD Convention)[186]

Aotearoa is also a party to the ENMOD Convention. The ENMOD Convention is an international disarmament law instrument prohibiting hostile environmental modification techniques.[187]

ENMOD explicitly proscribes "the use of the environment as a means of warfare",[188] with Article 1 stating that each State Party:[189]

> …undertakes not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party.

Article 2 defines "environmental modification techniques" as:[190]

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[184] Ralph Bodle, above n 177, at 321.
[185] Eleventh Meeting of the Conference of the Parties to the Convention on Biological Diversity, decision XI/20 (2012) at para 1; Thirteenth Meeting of the Conference of the Parties to the Convention on Biological Diversity, decision XIII/14 (2016) at para 1.
[186] ENMOD, above n 19.
[187] ENMOD, above n 19.
[188] International Committee of the Red Cross *1976 Convention on the Prohibition of Military or any Hostile Use of Environmental Modification Techniques* (Advisory Service on International Humanitarian Law, January 2003) at 1.
[189] ENMOD, above n 17, art 1.
[190] Article 2.

> …any technique for changing – through the deliberate manipulation of natural processes – the dynamics, composition or structure of the Earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space.

Although explicitly placing limitations on environmental modification, ENMOD does not apply to peaceful efforts to combat climate change. Statements in the preamble of ENMOD can support such a conclusion. The preamble recognises "that scientific and technical advances may open new possibilities with respect to modification of the environment"[191] and:

> …the use of environmental modification techniques for peaceful purposes could improve the interrelationship of man and nature and contribute to the preservation and improvement of the environment for the benefit of present and future generations.

The Convention offers no regulation nor rules for when the "peaceful" use of environmental modification techniques may or may not be allowed, simply stating:[192]

> The provisions of this Convention shall not hinder the use of environmental modification techniques for peaceful purposes and shall be without prejudice to the generally [recognised] principles and applicable rules of international law concerning such use.

The language adopted by ENMOD signals that the drafters have considered the potential, peaceful utility of environmental modification techniques, such as SAI geoengineering. The instrument would unlikely prohibit geoengineering activities unless hostile intent could be proven. This convention may regulate SAI geoengineering where use is threatened for coercive purposes[193] such as to create a "termination shock",[194] but the Conventions' reach only goes this far. Furthermore, it may prove tricky in application, as states can never be sure of another's intent behind their actions. It is crucial to maintain the distinction between law applying to times of peace and that in the context of armed conflict.[195] This distinction should not lightly be eroded.[196] SAI geoengineering deployed to limit warming falls under the status of generally

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[191] ENMOD, above n 17, preamble.
[192] Article 3(1).
[193] Adam Lockyer and Jonathan Symons, above n 140, at 493.
[194] At 493.
[195] Ralph Bodle and Sebastian Oberthür *Options and Proposals for the International Governance of Geoengineering* (Federal Environmental Agency, Climate Change 14, 2014) at [5.1.2.6].
[196] At [5.1.2.6].

acceptable activities under ENMOD. For these reasons, the Convention is not adequate to regulate SAI activities.

3 1985 Vienna Convention for the Protection of the Ozone Layer (Vienna Convention)[197]

Aotearoa is a party to both the Vienna Convention and the Montreal Protocol.[198] The Vienna Convention created obligations on states to "protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer".[199] The Vienna Convention developed a comprehensive compliance procedure for states, through the Montreal Protocol.[200] The protocol was designed to facilitate "global cooperation in reversing the rapid decline in atmospheric concentrations of ozone".[201] Under the protocol, all countries agreed to phase out the production and use of certain ozone harmful substances and chemicals.[202]

Scientists and scholars have commonly cited SAI activities, particularly those using sulphate particles, as a threat to restoring the ozone layer. Deployment could, therefore, potentially implicate the Vienna Convention and the Montreal Protocol.[203] However, the first obvious weakness of the Vienna Convention and Montreal Protocol are their inability to regulate SAI methods that pose no threat to the ozone, which potentially includes non-sulphate based proposals such as calcium carbonate.

The Vienna Convention does not specify substances to be controlled – however, it does contain an annexe of substances suspected to be problematic.[204] The substances contained in SAI are not included within that list.[205] However, the list is non-exhaustive, therefore, non- conclusive. Given its' potential to harm the ozone, sulphate-based SAI methods may reach the threshold set by this convention. Thus, SAI activities could potentially trigger this Convention.[206] Nevertheless, Ralph Bodle and Sebastian Oberthür highlight the flexibilities of the Vienna

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197 Vienna Convention, above n 18.
198 "Vienna Convention and the Montreal Protocol" (May 2019) Ministry for the Environment: Manatū Mō Te Taiao <www.environment.govt.nz>.
199 Vienna Convention, above n 18, art 2(1).
200 Montreal Protocol on Substances that Deplete the Ozone Layer 1522 UNTS 3 (opened for signature 16 September 1987, entered into force 1 January 1989). [Montreal Protocol].
201 Montreal Protocol, above n 200.
202 Montreal Protocol, above n 200.
203 Natalie Jones, above n 183; Kelsi Bracmort and Richard K Lattanzio, above n 171, at 35.
204 Vienna Convention, above n 18, annex I at [4].
205 Ralph Bodle and Sebastian Oberthür, above n 195, at [5.1.3.2].
206 See Ralph Bodle and Sebastian Oberthür, above n 195, at [5.1.3.2].

Convention, stating it “does not require its parties to take concrete measures to reduce ozone-depleting substances like H2S and SO2 could be considered to be”.[207] Thus, arguably the Convention does not adequately regulate SAI activities, as it neither prohibits nor significantly restricts H2S or SO2 from being introduced or released into the stratosphere.[208]

However, the Montreal Protocol contains concrete measures for parties – whilst maintaining the ability to amend and widen the scope of the Protocol flexibly.[209] The coverage has been widened considerably since its implementation, mainly subjecting more substances to the regulations.[210] Nonetheless, both H2S and SO2 have not yet been included within their scope. Therefore, Reynolds argues that although SAI may potentially slow and hinder the recovery of the stratospheric ozone, parties to the Protocol “would need to take action to regulate the material as a controlled ozone-depleting substance”.[211]

Despite the ability for the Montreal Protocol to include these substances within its ambit, it would regulate only their import, export, production and consumption, as distinct from their use or emission.[212] Therefore, Bodle and Oberthür argue that including these substances “would restrict [SAI] only to the extent that the restrictions imposed on production or import of these substances would affect the actual carrying out of the activity”.[213]

The convention is not adequate to regulate SAI activities.

4 Conclusion on International Conventions and Frameworks

On its face, the ENMOD should significantly influence parties to the agreements’ behaviour than non-binding instruments such as the CBD COP decisions.[214] The reason for this being that agreements formed in binding treaty negotiations are assumed to have a greater influence on state party behaviour than agreements formed under non-binding (soft law) instruments.[215] However, this assumption does not hold in the context of SAI – given the widely accepted view

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[207] Ralph Bodle and Sebastian Oberthür, above n 195, at [5.1.3.2].
[208] At [5.1.3.2].
[209] At [5.1.3.2].
[210] At [5.1.3.2].
[211] Jesse L Reynolds “Solar geoengineering to reduce climate change: a review of governance proposals” (2019) 475 Proc R Soc A 1 at 8.
[212] Ralph Bodle and Sebastian Oberthür, above n 195, at [5.1.3.2].
[213] At [5.1.3.2].
[214] Daniel Bodansky “The who, what, and wherefore of geoengineering governance” (2013) 121 Climatic Change 539 at 542.
[215] At 542.

amongst international law scholars that ENMOD unlikely applies to SAI activities unless conducted for military or hostile purposes.[216]

Furthermore, although the CBD guidance is non-binding on parties, soft law instruments can often be highly effective. Bodansky argues that this is true in the case of paragraph 8(w) of the 2010 COP decision, as "although not legally binding, may have a bigger direct effect on geoengineering activities because they delineate more precisely what states can and cannot do".[217] Furthermore, the COP decision may incite a bottom-up approach, allowing states to adopt more clear and ambitious commitments than they would agree to if binding in nature.[218] Part V will come back to this point, arguing that such an approach may be taken under Aotearoa domestic law.

The Vienna Convention and the Montreal Protocol do not adequately regulate SAI activities. Although, on its, face the Convention and Protocol appear to directly regulate SAI, given its potential to affect the ozone, the above analysis demonstrates the pitfalls in the instruments' abilities to have such an effect.

The international Conventions, while having some application to SAI activities, provide a stopgap, at best. Ultimately, no comprehensive regulation of SAI appears in an international convention or framework.[219] It can be reasonably concluded that introducing SAI into the stratosphere is not presently prohibited or even necessarily restricted by international conventions.

The next part will determine whether existing international customs and principles adequately regulate SAI in light of the lacuna.

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[216] Kerryn Brent, Jeffrey McGee and Jan McDonald "The Governance of Geoengineering: An Emerging Challenge for International and Domestic Legal Systems?" (2015-2016) 24(1) Journal of Law, Information and Science 1 at 25.
[217] Daniel Bodansky, above n 214, at 543.
[218] At 542.
[219] Janos Pasztor, above n 6, at 425.

B International customs and principles

1 No-Harm Rule

Customary international law is a set of legally binding rules on states'.[220] These rules become custom and gain legally binding status as "they are derived from states' repeated [behaviour] and evidence that they do so out of a sense of legal requirement".[221] Prima facie, each state is empowered under the customary rule of sovereign right to exploit their natural resources.[222] According to Reynolds, this sovereign right therefore implies:[223]

> that states have a presumptive right to conduct solar geoengineering activities within their own territory, provided that they do so in a manner consistent with their other rights and obligations, particularly regarding transboundary risks and harm.

Such a conclusion may also be supported by the reference to article 3 in the 2010 CBD COP decision X/33 paragraph 8(w).[224] Therefore, the sovereign right is qualified by the no-harm rule, whereby states can be held liable for causing transboundary harm.[225] States' have a legal duty to prevent transboundary environmental harm from occurring from activities within their jurisdiction or under their control.[226] The no-harm rule arose parallel to the rule of state sovereign right, and the two are commonly considered "two sides of the same coin".[227] In 1996, the International Court of Justice (ICJ) confirmed the rule's status as customary international law in their Advisory Opinion for *Legality of the Threat or Use of Nuclear Weapons.*[228]

The duty does not impose an obligation to ensure no transboundary environmental harm occurs.[229] Instead, the duty is one of prevention – requiring states to practice due diligence for activities that pose a risk of significant transboundary environmental harm.[230] The International Law Commission (ILC) concluded, through its Draft Articles on Prevention of Transboundary

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[220] Jesse L Reynolds, above n 22, at 84.
[221] At 84.
[222] Jesse L Reynolds, above n 22, at 85.
[223] At 85.
[224] Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity, above n 175, at [8(w)].
[225] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 49.
[226] Jesse L Reynolds, above n 22, at 85.
[227] At 85.
[228] *Legality of the Threat or Use of Nuclear Weapons (Advisory Opinion)* [1996] ICJ Rep 226.
[229] *Report of the International Law Commission on the work of its fifty-third session* [2001] vol 2, pt 2 YILC 147 at 154; Jesse L Reynolds, above n 22, at 86.
[230] Jesse L Reynolds, above n 22, at 86.

Harm from Hazardous Activities, that "different types of activities could be envisaged"[231] to trigger the duty to prevent transboundary harm. Such activities include "any hazardous and by inference any ultrahazardous activity which involves a risk of significant transboundary harm".[232] Therefore, both high-risk activities and activities "with a danger that is rarely expected to materialise but might assume, on that rare occasion, grave (more than significant, serious or substantial) proportions".[233]

In circumstances where the side effects of SAI reach the no-harm rule's threshold of risk of significant transboundary harm, the state who deployed such technique exposes itself to potential claims of state responsibility.[234] Brent and others have suggested that the no-harm rule might play a role in regulating SAI's risks of transboundary harm.[235] Therefore despite the lack of comprehensive international SAI regulation, the no-harm rule potentially presents itself as an avenue for states suffering damage due to SAI geoengineering deployment.

Once it has been established that the activity meets the "risk of significant transboundary harm" threshold, states must take preventive measures to comply with the duty on the standard of due diligence.[236] The ILC concluded:[237]

> due diligence is manifested in reasonable efforts by a State to inform itself of factual and legal components that relate foreseeably to a contemplated procedure and to take appropriate measures, in a timely fashion, to address them.

The due diligence standard imposed on a state is "roughly proportional to the probability and the magnitude of the risk"[238] of environmental harm. Thus, a state must exercise a much higher vigour of due diligence for activities that pose a much higher risk.

Based on their different chains of causation, Kerryn Brent, Jeffrey McGee and Amy Maguire have situated the environmental risks of SAI into three categories of harm:[239]

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[231] *Report of the International Law Commission on the work of its fifty-third session,* above n 229, at 149.
[232] At 149.
[233] At 149.
[234] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 49.
[235] See Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10.
[236] *Report of the International Law Commission on the work of its fifty-third session,* above n 229, at 154.
[237] At 154.
[238] Jesse L Reynolds, above n 22, at 86; see *Report of the International Law Commission on the work of its fifty-third session,* above n 229, at 154.
[239] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 48.

(1) direct transboundary harm [which would include instances of acid rain to neighbouring countries, caused by the particles falling into the troposphere].
(2) Indirect transboundary harm [which would include consequential effects of SAI such as droughts to neighbouring countries]; and
(3) harm to the global atmospheric commons [which would occur when the atmosphere itself is harmed without harm to other countries].

The potential harms imposed by SAI deployment are grave – thus, the no-harm rule may have a role to play here. However, how confident can we be in the no-harm rules' capacity in the geoengineering context? Particularly as it becomes difficult to establish a direct causal link between the SAI activity and the specific environmental damage encountered.[240] Some legal scholars doubt whether the duty to prevent transboundary environmental harm will, in practice, influence states decisions to implement SAI – with the legal content of this customary duty lacking clarity and possibly enforceability.[241]

As Brent, McGee and Maguire highlight in their article, the likelihood of the no-harm rule independently influencing the behaviour of states has been neglected in geoengineering governance literature.[242] Brent, McGee and Maguire suggest the no-harm rule may be more effective in regulating SAI than commonly accepted:[243]

> [the no-harm rule] warrants greater attention than it is currently receiving…[as] the perceived ambiguity regarding the content of the no-harm rule and its application to SRM may be reduced by more detailed legal analysis…[and] that strong international norms may operate to shape and constrain the behaviour of states, even in the absence of effective enforcement mechanisms.

Brent, McGee and Maguire say that to argue that customary international law generally has little influence over a state's actions is directly at odds with the formalist assumption.[244] States comply with international law predominantly as it is the appropriate course of action in most

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240 Ralph Bodle, above n 177, at 307.
241 Daniel Bodansky "May We Engineer the Climate?" (1996) 33 Climatic Change 309 at 312-313.
242 Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 49.
243 At 52-53.
244 At 53.

circumstances.[245] Thus, regardless of enforceability, states may feel a firm legal obligation to comply voluntarily.[246]

Brent, McGee and Maguire's argument is convincing. However, the rules' application to SAI remains concerning. Daniel Bodansky has previously expressed concern regarding the ability of customary legal norms to regulate SAI activities adequately.[247] In Bodansky's view, the general principles of international environmental law "do not provide any straightforward answer to the question: would climate engineering be legally permissible?"[248] thus do not adequately regulate the method.

Much of the literature to date supports Bodansky's proposition that without the backing of formal governance or regulatory framework, these customary rules would be a feeble response to the harm caused by SAI.[249] Although the rule may discourage states from advancing SAI activities, the retrospective nature of the no-harm rule impedes its ability to prevent harm from occurring in the first place.[250] Liability under the obligation only comes into play only after the SAI activity has taken place.[251]

The arguments of Brent, McGee and Maguire are convincing. However, it may be a stretch to confidently assert that the no-harm rule can adequately regulate SAI geoengineering activities alone. For the reasons outlined, this paper is of the view that the no-harm rule cannot regulate SAI alone.

2 Precautionary Principle

The precautionary principle is a general principle of international environmental law.[252] Unlike customary law, general principles are not directly binding on states themselves but are instead implemented through treaties or customs.[253] The customary rules and principles of international law do not operate in a legal vacuum – thus, the precautionary principle can guide the

[245] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 58.
[246] At 58.
[247] Daniel Bodansky "May We Engineer the Climate?", above n 241, at 312-313.
[248] At 316.
[249] Ralph Bodle, above n 177.
[250] At 308.
[251] At 308.
[252] Jesse L Reynolds, above n 22, at 75.
[253] At 75.

interpretation of the no-harm rule. In applying this principle to the no-harm rule, the standard of due diligence should adapt to changing scientific knowledge as it arises.[254]

The precautionary principle has increased traction in international environmental law.[255] Precaution "is a legal tool to manage risk and uncertainty that is sometimes cited when confronting issues of emerging technologies".[256] Given the uncertainties clouding SAI, precaution is undoubtedly relevant.[257] The principle, which essentially involves both a substantive and procedural obligation, requires parties to take a more cautious approach to authorise and deploy activities where they pose threats of severe environmental harm.[258] Karen N Scott explains the procedural requirement of the principle:[259]

> As a matter of procedure, scientific uncertainty must be explicitly considered as part of the decision-making process and must not be used as justification to [authorise] activities that pose a risk of serious harm to the environment or to postpone cost-effective measures designed to prevent such harm.

It is generally well accepted that SAI methods pose environmental risks – however, to what extent and degree are uncertain.[260] Bodansky states:[261]

> It may be confidently predicted that should geoengineering move from the realm of speculation to concrete proposal, the precautionary principle would be invoked frequently and loudly at the international level.

Thus under one line of thought, the principle places the burden on SAI geoengineering proponents to prove that it is safe, as the deployment of such methods poses the risk of "irreversible or catastrophic harm".[262]

However, the precautionary principle can be argued both ways. Granted the dire trajectory of climate change coupled with the short remaining period before climate tipping points are reached, perhaps negligible scientific certainty cannot be a reason for postponing SAI

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[254] *Report of the International Law Commission on the work of its fifty-third session,* above n 229, at 158.
[255] Jesse L Reynolds, above n 22, at 77.
[256] At 77.
[257] Daniel Bodansky "May We Engineer the Climate?" above n 241, at 316.
[258] Karen N Scott, above n 19, at 341.
[259] At 341.
[260] At 343.
[261] Daniel Bodansky "May We Engineer the Climate?", above n 241, at 312.
[262] At 312.

geoengineering. This view might be supported by the articulation of the in the UNFCCCs Article 3.3 states:[263]

> The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors.

As embodied in the UNFCCC, precaution may call for the consideration of SAI, at least through research, to prevent further climate change.[264] Reynolds asserts that as the UNFCCC neither defines nor limits the term "precautionary measures", SAI could be included within its scope.[265] In other words, the actual wording of the UNFCCC article arguably provides legal standing for further pursuing SAI geoengineering research.[266] Nevertheless, as Bodle rightly notes, it would be too far of a stretch to interpret the wording of article 3(3) of the UNFCC as embodying a requirement to deploy SAI or other geoengineering measures.[267]

Scholars have put forward serious debate on the principle's meaning and utility in application to SAI and geoengineering more broadly, with some asserting the principle is incoherent and need only be applied narrowly.[268] The reality remains that these norms provide only "a general frame of reference"[269] instead of comprehensive regulation for geoengineering methods. Scott agrees that relying on the stand-alone principle is not enough to regulate or govern geoengineering (and therefore SAI), without a specific framework to guide action.[270]

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263 United Nations Framework Convention on Climate Change 1771 UNTS 107 (opened for signature 9 May 1991, entered into force 21 March 1994) art 3.3.
264 Jesse L Reynolds, above n 22, at 77.
265 At 78.
266 Ralph Bodle, above n 177, at 310-311.
267 At 311.
268 Jesse L Reynolds, above n 22, at 77.
269 Daniel Bodansky "May We Engineer the Climate?", above n 241, at 313.
270 Karen N Scott, above n 19, at 344.

How the precautionary principle applies to SAI is contestable, as the nature of the risks involved means the principle "can cut both ways".[271] Taking action to progress SAI involves a plethora of risks and ethical challenges, while not taking action may result in much worse results.[272] Ultimately, the precautionary principle is not suitable to regulate SAI geoengineering activities. State's should not rely on the principle alone to guide research and development. The principles ability to regulate SAI's existence is contested and weak. As such, a lacuna in geoengineering regulation remains.

3 Conclusion on the no-harm rule and precautionary principle

Following Bodansky's line of thought, customary international norms, such as the no-harm rule, are tenuous at best in regulating geoengineering techniques. [273] Whether they can adequately deter states from attempting to deploy geoengineering methods is questioned.[274] Given the difficulties in successfully proving causation, enforcement is challenging.[275] Furthermore, the international system is arguably inadequately equipped to bind countries to settle disputes – lacking binding mechanisms.[276]

Admittedly, both the customary no-harm rule and the precautionary principle have a vital role in providing a predictable international legal framework. However, these rules "cannot carry the burden of guiding global climate action"[277] on their own. This is concerning as SAI would undoubtedly exacerbate tensions between states and risk harm to the commons and intergenerational impacts.

C Conclusion on the international regulation of SAI

It can reasonably be asserted that the introduction of SAI activities to supplement mitigation and adaptation methods is not presently legally prohibited or significantly restricted by the leading international conventions regulating SAI substances. The relevant international conventions were developed before SAI becoming a pressing issue, and the extent of their

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[271] Janos Pasztor, above n 6, at 426.
[272] At 426.
[273] Daniel Bodansky "May We Engineer the Climate?", above n 241.
[274] At 313.
[275] Kerryn Brent, Jeffrey McGee and Amy Maguire, above n 10, at 52.
[276] Daniel Bodansky "May We Engineer the Climate?", above n 241, at 313.
[277] Jutta Brunnée, above n 38, at 220.

application reflects this. However, decision X/33 paragraph 8(w) of the 2010 CBD COP appears to have the most significant ability to provide *de facto* limits to SAI.

It is difficult to gauge the effectiveness of the customary duty to prevent transboundary environmental harm concerning SAI at this stage. However, this paper has argued that it is not adequate to regulate SAI activities for reasons previously outlined. The precautionary principle does not provide helpful or meaningful guidance in this governance or regulatory dilemma. Developing and deploying SAI presents risks and implications, much in the same vein as the impacts and risks from omitting such action.

The international community currently lacks comprehensive SAI geoengineering regulation – yet unable to reach global consensus or develop global governance on the matter.

D Movement in the geoengineering governance sphere?

Despite the plethora of publications recommending specific ways to govern and regulate SAI (and geoengineering more generally), little has been achieved.[278] As mentioned, there exists no comprehensive international framework to govern SAI or any geoengineering measures. In 2019 at the fourth UN Environment Assembly (UNEA), an incremental movement was made when Switzerland tabled a draft resolution proposing enhanced international governance on geoengineering activities.[279] The draft resolution would have requested UNEP to collect and prepare relevant information on the risks and governance challenges of CDR and SRM geoengineering.[280] The effect of the draft resolution would have enabled better-informed development of international policy on SAI. However, due to the opposition of several member States, the resolution was withdrawn. It may potentially be re-submitted by the UNEA at its fifth session. However, the forum may not be the most appropriate to govern geoengineering. Moreover, lumping CDR and SRM methods together is not the best way to approach regulation or governance due to the inherent differences they pose.

Tackling climate regulation is not a simple task for international law. Given the complexities of proposed geoengineering activities, it is hardly surprising that international legal regulation

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278 Janos Pasztor, above n 6, at 425.
279 United Nations Environment Assembly of the United Nations Environment Programme *Proceedings of the United Nations Environment Assembly at its fourth session* UNEP EA.4/2 (11-15th March 2019) at [84].
280 United Nations Environment Assembly of the United Nations Environment Programme *Proceedings of the United Nations Environment Assembly at its fourth session,* above n 279, at [84].

and governance is at an impasse. How can states, political leaders, local communities and individuals be prompted to prioritise these issues and agree to them?[281] Some commentators have suggested that the collective nature of climate change (and thus applicable to SAI geoengineering) impede effective policies or the implementation of such.[282] The lack of consensus at the fourth UNEA is concerning and may infer a long road towards geoengineering governance and regulation at a global scale.

Against this background, domestic law should be considered – to assess what safeguards are in place to prevent SAI that goes beyond "small-scale" research to safeguard against transboundary implications.

V Strengthening Domestic Capacity to Regulate SAI in Aotearoa

Regulating SAI through domestic law alone is not the desired approach, given global and transboundary impacts. SAI requires governance and regulation at an international level before domestic systems can permit large-scale deployment. However, the application of international law to SAI appears to be at an impasse. Given the current lack of international safeguards and slow movement towards reaching consensus, it is vital to consider domestic law's role in preventing large-scale SAI activities from being deployed.

This part assesses Aotearoa's current domestic regulatory effect on SAI – noting that a domestic prohibition could safeguard and strengthen Aotearoa's position.

A Role of Domestic Regulation

Legal research on geoengineering regulation has primarily focussed on the international context – namely, how existing international legal rules, norms, principles and treaty regimes may apply and respond to the different proposed technologies.[283] On the whole, legal research into the application of existing international principles and customs demonstrates considerable gaps in its capacity to regulate SAI activities adequately.[284]

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[281] Jutta Brunnée, above n 38, at 217.
[282] At 217.
[283] Kerryn Brent, Jeffrey McGee and Jan McDonald, above n 216, at 24.
[284] At 25.

Due to the lack of meaningful regulation of SAI under international law, the onus is placed on domestic legal systems, although SAI risks are transboundary in scope. Individual states can amend domestic law to narrow the scope of permitted activities and prohibit activities altogether.

Notably, Brent, McGee and McDonald highlight the general scarcity of current research on domestic regulation - suggesting further research to explore this gap.[285] The fact that little attention has been given to domestic law's role in regulating SAI is somewhat surprising – considering the "broader devolutionary trend in the climate governance literature"[286] and lack of meaningful international safeguards.

This part aims to build on the current literature[287] by delving into Aotearoa's national regulation, which may apply. This part concludes in favour of limiting the scope for SAI to be permitted in Aotearoa.

1 SAI in Aotearoa?

In December 2020, the government of Aotearoa declared a climate emergency, committing the nation to urgent action to reduce emissions.[288] The decision came following the IPCC's sobering findings that to avoid levels of 1.5°C warming, global emissions need to drop approximately 45 per cent from 2010 levels by 2030.[289] Aotearoa is a relatively significant contributor to greenhouse gas emissions, contributing the fifth-highest per capita emissions of UNFCCC's developed countries.[290] The people of Aotearoa have long advocated for declaring a climate emergency – and rightly so with Aotearoa's disproportionately high historical emissions in mind and deteriorating position of its people and land to the impacts of climate change. Declaring a climate emergency reflects positive movement for Aotearoa. Nevertheless, what does it mean in execution for Aotearoa?

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285 Kerryn Brent, Jeffrey McGee and Jan McDonald, above n 216, at 33.
286 Sikina Jinnah, Simon Nicholson and Jane Flegal "Toward Legitimate Governance of Solar Geoengineering Research: A Role for Sub-State Actors" (2018) 21(3) Ethics, Policy & Environment 362 at 364.
287 See Kelsi Bracmort and Richard K Lattanzio, above n 171; Chiara Armeni and Catherine Redgwell "Geoengineering Under National Law: A Case Study of the United Kingdom" (9 March 2015) Climate Geoengineering Governance <www.geoengineering-governance-research.org>; Ralph Bodle and Sebastian Oberthür, above n 195.
288 LabourVoices "New Zealand declares climate emergency" (2 December 2020) Labour <www.labour.org.nz>.
289 LabourVoices, above n 288.
290 Rhys Jones, Hayley Bennett, Gay Keating and Alison Blaiklock, above n 60, at [9].

In Aotearoa, there is no evidence which indicates that research or development is being conducted into SAI. However, other forms of high-altitude activities are currently being conducted, with Aotearoa's Ministry of Business, Innovation and Employment (MBIE) website stating:[291]

> We already have high-altitude activity happening from New Zealand. These range from small, uncontrolled balloons launched for the purpose of collecting weather data or educating students, to large controllable balloons carrying sophisticated imaging and communications equipment for scientific research.

Furthermore, the rapid development of Aotearoa's space industry has perhaps opened the door to a range of future technological advancements. Aotearoa has taken a significant interest in funding space-based technology to combat climate change.[292] Given the "remote location…clear skies and seas, and relatively low levels of air traffic",[293] Aotearoa is believed to provide an excellent location for participation in the global space economy. The same conclusion could therefore be made of its site in regards to SAI technologies.

Significantly then, how would SAI be regulated under current laws or policies? Efforts by Aotearoa's government in developing policies to address the emergence of controversial technologies is well documented (take, for example, bans on nuclear energy[294] and laws governing gene editing[295]). In the context of SAI, this paper considers that the plethora of social, ethical and transboundary environmental hazards and risks[296] SAI may pose, may provide a reason for taking a stricter approach – as will be outlined.

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[291] "Our regulatory regime" Ministry of Business, Innovation and Employment <www.mbie.govt.nz>.
[292] See Malcolm Scott "A space tourism destination: environmental, geopolitical and tourism branding considerations for New Zealand as a 'launch state'" (2020) Journal of Sustainable Tourism 1; "Space-related opportunities in New Zealand" (2 October 2020) Ministry of Business, Innovation and Employment <www.mbie.govt.nz>.
[293] "Space-related opportunities in New Zealand" (2 October 2020) Ministry of Business, Innovation and Employment <www.mbie.govt.nz>.
[294] For example, Aotearoa introduced legislative bans, establishing New Zealand as a Nuclear Free Zone, see New Zealand Nuclear Free Zone, Disarmament, and Arms Control Act 1987.
[295] Aotearoa has developed a comprehensive legal framework for genetic editing through a combination of legislation and regulations from gene editing advisory boards, see Human Assisted Reproductive Technology Act 2004; Hazardous Substances and New Organisms Act 1996; Medicines Act 1981.
[296] Kelsi Bracmort and Richard K Lattanzio, above n 171, at 24.

2 *Current domestic laws restricting or regulating SAI*

This part intends to illustrate the strengths, holes and weaknesses of Aotearoa's domestic regulation which may apply to SAI activities.

(a) Ozone Protection Laws

As SAI activities that utilise sulphate particles risk ozone depletion to some degree,[297] regulation may to some extent fall under the Ozone Layer Protection Act 1996 and the Ozone Layer Protections Regulations 1996, which prohibits ozone-depleting substances.[298] The Act and regulations were implemented in response to Aotearoa's commitments to upholding their obligations under the Vienna Convention and the Montreal Protocol.[299] Per the Montreal Protocol, Aotearoa New Zealand phased out the import and manufacturing of ozone-depleting substances and goods.[300]

The Act prohibits the import, manufacture, sale or export of the controlled substances except as allowed under the Regulations.[301] Schedule 1 of the regulations lists controlled substances, including hydrochlorofluorocarbons (HCFCs), methyl bromide, and other substances, including halons, chlorofluorocarbons, and carbon tetrachloride, methyl chloroform and hydrobromofluorocarbons.[302]

The substances contained in stratospheric sulphate aerosols (which are the most studied materials for SAI[303]) include sulphur dioxide, carbonyl sulphide, and sulphuric acid,[304] appear to have been omitted from the list of prohibited or controlled substances contained in the regulations.[305] Exclusion from the list of prohibited or controlled substances presumably places the materials outside the scope of ozone-depleting substances, strictly controlled or prohibited in Aotearoa.

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[297] See "SCoPEx: Stratospheric Controlled Perturbation Experiment" Keutsch Group at Harvard <www.keutschgroup.com>.
[298] Ozone Layer Protection Act 1996, s 6; Ozone Layer Protections Regulations 1996.
[299] "Vienna Convention and the Montreal Protocol", above n 198.
[300] "Vienna Convention and the Montreal Protocol", above n 198.
[301] Ozone Layer Protection Act 1996, s 16.
[302] Ozone Layer Protection Regulation 1996, sch 1.
[303] "SCoPEx: Stratospheric Controlled Perturbation Experiment", above n 297.
[304] David Llanos "Stratospheric Aerosol Injection – Solar Radiation Management" (PH240 coursework, Stanford University, 2015).
[305] See Ozone Layer Protection Regulation 1996, sch 1.

However, the Act maintains the flexibility of the Montreal Protocol, enabling the making of regulations to control ozone-depleting substances further, therefore broadening the ambit of controlled substances.[306]

Nonetheless, in the case that SAI materials *were* prohibited under the Act, the Environmental Protection Authority (EPA) has authority to "grant an exemption from any prohibition on the importation, exportation, manufacture, sale or use of any substance or goods".[307] In considering an application for exemption, the EPA must pay regard to "the need to protect human health and the environment from adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer".[308] The ambit of this power appears wide enough to permit SAI substances in cases where anthropogenic climate change threatens human health and the environment.

The scope of the Act and regulations would not include substances that do not risk ozone depletion. Therefore, SAI substances such as calcium carbonate, proposed as an alternative to sulphates, would not be regulated. Laboratory results indicated this material "could reduce ozone loss"[309] compared to sulphate aerosols, which have ozone-depleting qualities.[310]

(i) Conclusion

These laws could be strengthened to potentially narrow the scope of permitted SAI use by introducing explicit restrictions on substances containing ozone-depleting species proposed for SAI use. The Act grants authority to the EPA to grant exemptions, which may potentially make further inclusions redundant.

However, as discussed with the Vienna Convention and Montreal Protocol, ozone laws are not an adequate framework to regulate the potential use of SAI technologies. Ozone laws could provide only a stopgap to these activities. Furthermore, as Bodle and others pointed out with the Vienna Convention and Montreal Protocol – it could restrict SAI only to the extent that the restrictions and prohibitions placed on the manufacturing or import of these substances affect

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306 Ozone Layer Protection Act 1996, part 3.
307 Section 8.
308 Section 9(a).
309 "SCoPEx: Stratospheric Controlled Perturbation Experiment", above n 297.
310 Heleen de Coninck and others, above n 11, at 349.

the actual research or deployment of the activities.[311] The Act could not regulate proposed SAI substances that do not risk ozone depletion.

(b) Civil Aviation Act 1990[312]

The Civil Aviation Act 1990 would inevitably have some bearing over SAI activities in Aotearoa. "Aircraft" is defined broadly in the Civil Aviation Act and includes balloons.[313] SAI activities are regulated by the Act as the operator must hold the necessary approvals, permits, certificates or documents for the operation of the aircraft.[314] However, there is limited and inadequate scope to prevent SAI activities from being deployed or to manage their operation.[315] The Act deals only with aviation safety and has no regulatory powers to control activities that threaten national security or are not considered in the national interest.[316] Furthermore, SAI operations themselves appear to operate above the regulated aviation space.

(i) Conclusion

The Civil Aviation Act is not itself adequately equipped to regulate SAI activities.

(c) The Outer Space and High-altitude Activities Act 2019 (OSHAA)[317]

OSHAA entered force in 2017, making Aotearoa amongst the first nations to implement laws regulating non-rocket propelled activities in high altitudes.[318] OSHAA established a regulatory framework governing space activities and certain high-altitude activities,[319] which was necessary following the establishment of commercial space launch operations in Aotearoa with Rocket Lab.[320]

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311 Ralph Bodle and Sebastian Oberthür, above n 195, at [5.1.3.2].
312 Civil Aviation Act 1990.
313 Section 2(1).
314 Section 4.
315 Katherine MacNeill *Regulatory impact statement: The Outer Space and High-altitude Activities Act 2017 Regulations* (Ministry of Business, Innovation and Employment, Regulatory Impact Statement, 14 August 2017) at 6.
316 Simon Martin and Josie Desmond "The Space Law Review: New Zealand" (17 December 2020) The Law Reviews <www.thelawreviews.co.uk>.
317 Outer Space and High-altitude Activities Act 2017.
318 "Space-related opportunities in New Zealand", above n 293.
319 Outer Space and High-altitude Activities Act 2017, s 3(e).
320 Malcolm Scott, above n 292, at 1.

SAI activities appear to fall within the ambit of “high-altitude”, which is defined as:[321]

> …an altitude above the higher of -
>
> (a) flight level 600; and
> (b) the highest upper limit of controlled airspace under the Civil Aviation Act 1990.

Flight level 600 is equal to 60,000 feet or approximately 18 kilometres above ground.[322] However, the Act leaves the upper limit of “high-altitude” areas unspecified. As “outer space” is also left undefined in the Act, it is not clear at what point Aotearoa’s airspace ends, nor where “outer space” begins. However, this is of no concern for SAI activities, which operate in the stratospheric layer of the atmosphere, and therefore fall within activities operating at high altitudes. SAI activities envisage dispersing various chemical particles from a balloon at an altitude of approximately 20 kilometres above ground.[323]

The inclusion of high-altitude activities into the regime was intended to future-proof the regime for developments in technology.[324] The Act intends to capture:[325]

> …a range of technologies being developed to operate at very high altitudes (near space) and performing similar functions to satellites, including Earth observation, internet connectivity and surveillance activities.

The launch vehicles of SAI proposed activities do not appear to be included within the exemptions to the Act,[326] therefore, appear to be within the ambit of regulated activities. In this regard, the Act may be interpreted as a bottom-up approach to regulating SAI activities – providing domestic regulation where international regulation is yet to be agreed to. It must be noted that whether SAI fall within the ambit is untested and should be clarified in the future for certainty. The following assessment of the Act continues on the assumption that it would apply to SAI activities to some extent.

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[321] Outer Space and High-altitude Activities Act 2017, s 4.
[322] “Regulatory Impact Statement: Outer Space and High Altitude Activities Bill” (8 June 2016) (obtained under the Official Information Act 1982, agency disclosure statement) at [79].
[323] Jeff Tollefson “The Sun Dimmers” (2018) 563 Nature 613 at 613.
[324] Katherine MacNeill, above n 315, at 7.
[325] “Regulatory Impact Statement: Outer Space and High Altitude Activities Bill”, above n 322, at 1.
[326] See Outer Space and High-altitude Activities (Definition of High-altitude Vehicle) Regulations 2017, cl 5; Outer Space and High-Altitude Activities Act 2017, s 4; New Zealand Space Agency “Application Guidance – High-altitude Licence” <www.mbie.govt.nz>.

Under this regulatory regime, licences or permits are required to launch and operate high-altitude payloads from Aotearoa,[327] which explicitly includes loads "to be carried for testing purposes or otherwise on a non-profit basis".[328] This drafting further supports the assumption that SAI activities would be deemed within the ambit of the Act.

Several thresholds apply to the granting of licences or permits under the Act. In addition to holding the necessary approvals and authorisations required under the Civil Aviation Act 1990,[329] the applicant must prove:[330]

- [they have] the technical capability to safely conduct the proposed activity – for example, a safe launch, or safe operation of the payload;
- [they] will take, and continue to take, all reasonable steps to manage risks to public safety;
- that the proposed activity is consistent with New Zealand's international obligations.

Part 2, schedule 6 of the Outer Space and High-altitude Activities (Licences and Permits) Regulations 2017, sets out the information required for licences concerning a high-altitude vehicle that is not aircraft.[331] The applicant must provide a safety assessment identifying any public safety risks associated with the activity;[332] the nature, likelihood and consequences of the risks;[333] geographical areas likely to be affected by conducting the activity;[334] and measures the applicant will implement or has implemented to minimise the risks presented to public safety.[335] Interestingly, the regulations do not require an applicant to provide the outlined information in relation to each high-altitude vehicle that *is* an aircraft.[336] Therefore, presumably, obtaining a licence for SAI methods conducted in aircraft would not require consideration of these matters.

The Act provides the Minister with additional authority to potentially safeguard against activities which may be controversial. Even if the Minister is satisfied the applicant has met

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[327] Outer Space and High-altitude Activities Act 2017, part 2.
[328] Section 4.
[329] Section 47(1)(b)(i).
[330] "Outer space and high-altitude activities regulatory system" Ministry of Business, Innovation and Environment (15 November 2019) <www.mbie.govt.nz>.
[331] Outer Space and High-altitude Activities (Licences and Permits) Regulations 2017, part 2, sch 6.
[332] Part 2, sch 6(9)(d)(i).
[333] Part 2, sch 6(9)(d)(ii).
[334] Part 2, sch 6(9)(d)(iii).
[335] Part 2, sch 6(9)(d)(iv).
[336] See Part 2, schedule 6, part 1.

the requirements, the Minister may decline to grant a high-altitude licence if they are not satisfied the launch is in the national interest.[337] In deciding whether or not a launch is in the national interest, the Minister may consider "any risks to national security, public safety, international relations, or other national interests"[338] and any further matters the Minister considers relevant.[339] The Minister has the discretion to decide what constitutes an activity not within the national interest. The Cabinet Paper has detailed matters that would not be in Aotearoa's national interest, including "payloads where the intended end use is likely to cause serious or irreversible harm to the environment".[340] With these considerations in mind, it may be safely concluded that the Minister would likely reject applications for SAI testing which was not considered adequately controlled.

In addition to imposing a licensing regime for high-altitude activities, the Act creates offences for individuals and body corporates operating without the relevant licence,[341] launching a payload without a payload permit,[342] or failing to comply with a licence or permit.[343] For each offence, the maximum penalty for an individual is one year's imprisonment or a fine not exceeding $50,000, or both; and for a body corporate, a fine not exceeding $250,000. Imposing criminal offences of this nature for breaches of the regime are highly desired in the context of SAI. The offences reflect the seriousness of offending.

The regime provides a flexible regime which is able to respond to emergent technologies. However, whether adequate consideration to safeguarding the environment, ethical concerns and treaty obligations have been made, is questioned. Prior to the enactment, a government cabinet paper noted that to "capitalise on the emerging economic opportunities"[344] presented by Rocket Lab, the government needed to "rapidly develop our policy and regulatory capability".[345] The rapid development of the regulation has been criticised as a potentially

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[337] Outer Space and High-altitude Activities Act 2017, s 47(2).
[338] Section 47(3)(b).
[339] Section 47(3)(d).
[340] Hon Phil Twyford *Approach to payload assessments under the Outer Space and High-Altitude Activities Act* (Ministry for Economic Development, 25 November 2019) at [11] and [13].
[341] Outer Space and High-altitude Activities Act 2017, s 68.
[342] Section 66.
[343] Section 70.
[344] Office of the Minister for Economic Development and Science and Innovation Chair, Cabinet Economic Growth and Infrastructure Committee "The Scope of Space Policy and a Lead Space Agency" (2016) at [5] (obtained under Official Information Act 1982 proactive release).
[345] Office of the Minister for Economic Development and Science and Innovation Chair, Cabinet Economic Growth and Infrastructure Committee, above n 344.

reckless move by the government,[346] which has not entirely safeguarded the environment and other interests of the public. The regime may require further deliberation which will be elaborated on in the following part.

(i) Review of the Act

As soon as practicable after three years following the commencement of the Act, section 86 of the Act requires the responsible Minister to "commence a review of the operation and effectiveness of the Act".[347] The review began this year in August.[348] The review intends to inform the House of Representatives on matters concerning certainty, predictability, flexibility and transparency of the regime.[349] This paper considers that several matters concerning high-altitude activities should be considered in the review to strengthen the regimes applicability to SAI emergent technologies.

(a) Mandatory Environmental Considerations

This paper recommends reviewing environmental matters. As previously stated, applicants for licences and permits of high-altitude vehicles that are aircraft are not required to provide a safety assessment.[350] This paper recommends reviewing this regulatory matter.

This paper recommends a more rigorous approach to activities in the "national interest".[351] It may be beneficial to *require* that a Minister decline a high-altitude licence where to permit so would not be in the national interest. Additionally, the considerations a Minister can consider when determining whether an activity is in the national interest are discretionary. This paper recommends reviewing an approach where the Minister is required to have regard to any risks to the environment when making the assessment.

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[346] Malcolm Scott, above n 292, at 7.
[347] Outer Space and High-altitude Activities Act 2017, s 86(1).
[348] "Statutory review of space law starts" (17 August 2021) Ministry of Business, Innovation & Employment <www.mbie.govt.nz>.
[349] "Review of the Outer Space and High-altitude Activities Act 2017 Terms of Reference" <www.mbie.govt.nz>.
[350] See Outer Space and High-altitude Activities (Licences and Permits) Regulations 2017, part 2, sch 6, part 1.
[351] See Outer Space and High-altitude Activities Act 2017, ss 47(2)(a) and 47(3).

The purpose of the Act omits explicit mention of safeguarding the environment.[352] Furthermore, the Act itself provides minimal reference to environmental considerations. The Act is disappointing in this respect, requiring further review.

Stricter mandatory considerations and requirements regarding the environment and public safety should be considered, mainly due to the risks imposed by SAI and the lack of international consensus in governing such activities.

(b) Implementing a specific and predictable ban on SAI methods that do not breach decision X/33 paragraph 8(w)

This paper recommends that the Act could clarify its position to SAI activities. Given the lacuna in international regulation, and the potential ability for some SAI methods to be permitted in Aotearoa, stricter and specific regulation could be considered. As a party to the CBD, Aotearoa could consider explicitly strengthening its’ *de facto* international commitments by explicitly prohibiting SAI activities that are not small-scale research projects.[353]

The regime was enacted to respond to an area of rapid technological advancement and change to maintain flexibility, so the Act is “sufficiently technology-neutral”.[354] However, including specific reference to *de facto* obligations under the 2010 CBD COP decision X/33 paragraph 8(w) could effectively be drafted in such a way that does not undermine the flexibility of the Act’s purpose of maintaining flexibility. The purpose provision of the Act clarifies the purpose to “implement certain international obligations of New Zealand relating to space activities and space technology”,[355] including but not limited to the obligations outlined in the Outer Space Treaty.[356] The drafting maintains flexibility whilst ensuring that prohibiting certain activities are clearly within the purpose of the Act.

Explicitly including Aotearoa’s commitments to decision X/33 paragraph 8(w) would strengthen the certainty and predictability of the regime. This paper also proposes that in doing so, the government could clarify what is deemed small-scale research. This would have the effect of preventing liberal interpretations without completely inhibiting SAI research from

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[352] See Section 3.
[353] Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity, above n 175.
[354] “Review of the Outer Space and High-altitude Activities Act 2017 Terms of Reference” <www.mbie.govt.nz>.
[355] Outer Space and High-altitude Activities Act 2017, s 3(b).
[356] Section 3(c).

progressing. Enhancing certainty and predictability regarding what SAI research activities are legally permitted may enable Aotearoa to contribute more effectively in global governance, enhancing informed global decision making on the matter.

Even though Aotearoa would unlikely breach the non-binding moratorium in decision X/33 paragraph 8(w), additional action could be taken to ensure that fact. Aotearoa would benefit from unambiguous policies which enable "greater guidance for behaviour than general rules, which can be interpreted in self-serving ways".[357] The option is a relatively clean and straightforward approach, providing bright lines around the scope for SAI activities to go forward.

The implementation of bright-line rules has the attraction of avoided complexity.[358] Moratoriums or bans, however, may inherently pose risks in themselves. Advocates for geoengineering may argue that banning such development in its infancy would be ill-advised, inhibiting further research. States may views moratoriums of this nature as shooting themselves in the foot – impeding their international positioning. Bracmort and Lattanzio make note that bans may:[359]

> …deter only those countries, corporations, and individuals who are most likely to develop the technology in a responsible fashion, thus failing to discourage potentially dangerous experimentation by less responsible parties.

However, the groundings of such arguments are made redundant by the nature of the prohibition proposed – which does not propose to hinder SAI small-scale research.

Some warn against the premature implementation of regulation.[360] Caldeira argues, "pushing too early for formal agreements may lock political entities into hard positions that will be difficult to modify later".[361] Caldeira's argument may be plausible in the slow-moving international legal context wherein international consent impedes development. International cooperation is inherently conservative, wherein states often negotiate an agreement by adjusting their commitments to a safe level to ensure that compliance is not technically,

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[357] Daniel Bodansky "The who, what, and wherefore of geoengineering governance", above n 214, at 542.
[358] Daniel Bodansky "The who, what, and wherefore of geoengineering governance", above n 214, at 546.
[359] Kelsi Bracmort and Richard K Lattanzio, above n 171, at 23.
[360] (November 5 2009, February 4 2010 and March 18 2010) (Hearing before the Committee on Science and Technology: House of Representatives: One Hundred Eleventh Congress, prepared statement of Ken Caldeira) at 22.
[361] At 22.

economically, politically and socially cumbersome at the domestic level.[362] States can simply insert loose language to increase palatability if international commitments are perceived as too high or burdening to existing domestic frameworks and systems.[363] However, in the domestic context, legal amendment is far more fluid. If international negotiations on SAI progress, domestic laws can be terminated to align to international governance and regulation.[364]

Some consider direct efforts towards regulation for SAI methods as simply not a priority.[365] In 2010, the UK Government had considered no such urgency in developing regulation, with Minister Joan Ruddock not viewing geoengineering as a priority for the Government.[366] Ruddock's view fell on the fact that such techniques were far from viability.[367]

Ruddock's reasoning is no longer persuasive, particularly as geoengineering governance was tabled at the fourth UNEA.[368] Moreover, in 2021, researchers at Harvard University intended to conduct the first SAI geoengineering experiments in the stratosphere through the Stratospheric Controlled Perturbation Experiment (SCoPEx) project.[369] The researchers intended to deploy a small number of particles above Swedish territory to develop research into the risks and benefits of SAI.[370] Execution involved flying a balloon twenty kilometres above ground in Sweden to release the particles into the stratosphere.[371] The experiment was to be used to model and predict larger-scale effects and implications of SAI technologies.[372] However, following the recommendations of the Harvard University advisory committee, the project was suspended to allow for public consultation.[373] Although the project itself was arguably within the bounds of decision X/33 paragraph 8(w), it exposes movement towards SAI nonetheless. SCoPEx illustrates that "serious consideration for the regulatory

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[362] Kelsi Bracmort and Richard K Lattanzio, above n 171, at 29.
[363] Kelsi Bracmort and Richard K Lattanzio, above n 171, at 29.
[364] Jonathan Boston "Anticipatory Governance: how well is New Zealand safeguarding the future?" (2016) 12(3) Policy Quarterly 11 at 15-16.
[365] See House of Commons Science and Technology Committee *The Regulation of Geoengineering: Fifth Report of Session 2009-10* (18 March 2010) at 21.
[366] At 21.
[367] At 21.
[368] See United Nations Environment Assembly of the United Nations Environment Programme *Proceedings of the United Nations Environment Assembly at its fourth session,* above n 279, at [84].
[369] James Temple "Geoengineering researchers have halted plans for a balloon launch in Sweden" (2021) MIT Technology Review <www.technologyreview.com>; Jeff Tollefson "The Sun Dimmers", above n 337, at 613.
[370] James Temple, above n 369.
[371] Janos Pasztor, above n 6, at 423.
[372] Kristoffer Hætta "Petition: Support the Indigenous peoples voices call on Harvard to shut down the SCoPEx project" (9 June 2021) Saami Council <www.saamicouncil.net>.
[373] James Temple, above n 369.

arrangements for geoengineering needs to start now, not once highly disruptive climate change is under way".[374]

The uncertainties surrounding the capacity of international law to respond to threats of transboundary harm by geoengineering further suggests the dire need to address this legal lacuna.

Anticipatory governance requires states to look forward - protecting long-term public interests.[375] The approach attempts to "future-proof"[376] and "minimise future harms".[377] Anticipatory governance accepts that uncertainties exist and does not allow such to prevent regulatory preparedness.[378] Jonathan Boston argues that instead, anticipatory governance "embraces the need, given a dynamic and unpredictable world, for anticipatory planning and adaptive management".[379] Taking a prudent anticipatory approach to explicitly regulating SAI may reduce or eliminate risks of severe and irreversible damage that implicate the well-being of future generations.[380] The current domestic regulation status quo may be too flexible in its approach, given the transboundary risks of unilateral action where global consensus is yet to be reached.[381]

(c) Considering the human relationship with nature as a justification for a complete prohibition

Although outside of the listed matters that will be assessed in the review,[382] this paper recommends considering the human relationship with nature, which SAI threatens. In contrast to the previous recommendation, this view may justify prohibiting SAI activities altogether in Aotearoa, regardless of their scale and purpose.

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374 House of Commons Science and Technology Committee, above n 365, at 41.
375 Jonathan Boston, above n 364, at 11.
376 At 11.
377 At 11.
378 At 12.
379 At 12.
380 At 14.
381 Daniel Bodansky "The who, what, and wherefore of geoengineering governance", above n 214, at 548.
382 See "Review of the Outer Space and High-altitude Activities Act 2017 Terms of Reference" <www.mbie.govt.nz>.

The general distrust in geoengineering and reluctance to implement these strategies are not unjustifiably conservative – for it is anthropogenic practices that disrupted the global equilibrium, causing climate change, in the first place.[383]

Unsurprisingly, proposals to experiment with SAI technologies overseas have been met with widespread resistance,[384] particularly from indigenous communities who are amongst those most at risk of climate change.[385]

The SCoPEx proposal “caused some consternation”[386] and was met by widespread resistance. Indigenous voices from around the world urged Harvard University to abandon the research into the feasibility of such SAI methods.[387] In an open letter to the University, the Saami Council, on behalf of indigenous groups, demanded the halt of SAI research and technology until global consensus has been reached on its acceptability.[388] The Saami Council voiced strong concerns over the project, stating:[389]

> We do not approve legitimising development towards solar geoengineering technology, nor for it to be conducted in or above our land, territories and skies, nor in any ecosystem anywhere.

Along with the possible negative implications of deploying the technology itself, indigenous groups were concerned about the sacred relationship between Mother Earth and Father Sky, which SAI testing would violate.[390] Saami Council considers SRM technologies to be directly at odds with the Indigenous relationship with nature:[391]

> Our Indigenous worldview has taught us that humans are part of nature and that we need to live respectfully and not exploit natural resources, so that we can hand over healthy ecosystems to future generations. Solar geoengineering technology puts humans as

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[383] Valerie Fowles “Sea-questration: the effects of marine iron fertilization on phytoplankton carbon uptake in the Southern Ocean” (2020) 5(1) Canadian Journal of Undergraduate Research 17 at 21.
[384] Adrian Currie “Geoengineering tensions” (2018) 102 Futures 78 at 79-80.
[385] Subsidiary Body on Scientific, Technical and Technological Advice, above n 161, at 19.
[386] Janos Pasztor, above n 6, 422.
[387] Alister Doyle “Indigenous peoples urge Harvard to scrap solar geoengineering project” (10 June 2021) Reuters <www.reuters.com>.
[388] Letter from Christina Henriksen (President of the Saami Council) to Members of the SCoPEx Advisory Committee regarding the SCoPEx plans for test flights at the Swedish Space Corporation in Kiruna (24 February 2021).
[389] Alister Doyle, above n 387.
[390] Kristoffer Hætta, above n 372.
[391] Kristoffer Hætta, above n 372.

> masters of nature to control the whole earth, even the atmosphere, which is completely new and foreign for us.

Although SCoPEx was a small-scale project, and any potential impacts on the surrounding environment would have been minor, the Saami Council were concerned that these tests would represent the first step towards legitimising further development of SAI technology.[392] Geoengineering solutions such as SAI potentially open the flood-gates for further anthropogenic global alterations to suit humans.[393]

However, what is concerning is that the SCoPEx project was potentially in line with decision X/33 paragraph 8(w), which, as outlined earlier, provides:[394]

> No climate-related [geoengineering] activities that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts, with the exception of small scale scientific research studies that would be conducted in a controlled setting.

The project was a small-scale scientific research study set to be conducted in a controlled setting. The COP decision does not appear to require extensive consideration of social and cultural impacts in the context of small-scale research studies. This is concerning for indigenous voices and requires further consideration. The predicament exposes the difficulty in balancing interests towards scientific research to enable informed decision making and ethical and cultural concerns which reject permitting such.

The relationship between humans and the natural environment should be considered in conducting the review of OSHAA.

(d) Aotearoa's Indigenous Context – Treaty of Waitangi and mātauranga Māori

In carrying out the review, this paper recommends considering the Treaty of Waitangi and mātauranga Māori. Aotearoa holds culturally specific incentives which need to be considered.

[392] Kristoffer Hætta, above n 372.
[393] David W Keith, above n 91, at 277.
[394] Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity, above n 175, at [8(w)].

It is questioned whether Aotearoa's indigenous context was effectively recognised under the drafting of OSHAA. Greater integration of Māori perspectives should be considered to enable and empower iwi and hapū to protect Papatūānuku.[395]

The United Nations Development Group further highlights the importance of indigenous voices in climate decision-making, stating:[396]

> In the case of climate change, indigenous communities have contributed the least to the emission of carbon dioxide and other greenhouse gases because of their traditional practices, yet they are among the first to face direct adverse environmental, social and human consequences of climate change. Consequently, indigenous peoples must fully participate in the definition and implementation of policies and plans related to climate change impact mitigation.

Māori and other indigenous groups carry a long history of and an abundance of traditional knowledge over natural resource management – with much to contribute to effective climate strategies going forward.[397] Yet, no consultation has been made to determine whether SAI would respect mātauranga Māori, despite the potential for these methods to be licenced or permitted under OSHAA.

It may be challenging to reconcile SAI with te ao Māori. SAI potentially crosses ethical lines, or at least skirts on its boundaries – challenging the way Māori view the reciprocal relationship between nature and humanity. Ethical concerns regarding SAI have presented significant obstacles to the progression of geoengineering's international advancement and regulation.[398] But perhaps in Aotearoa's context, they might be the same incentive *for* enacting such regulation.

An issue with geoengineering and SAI techniques is that it potentially reinforces Western concepts of property to environmental management.[399] This is entirely problematic for failing

[395] Minter Ellison Rudd Watts "Resource management reform: Greater integration of Māori perspectives" (30 September 2020) <www.minterellison.co.nz>.
[396] United Nations Development Group *Guidelines on Indigenous Peoples' Issues*, above n 61, at 19.
[397] Rhys Jones, Hayley Bennett, Gay Keating and Alison Blaiklock, above n 60.
[398] Madelaine Pears, above n 149, at 12.
[399] See Rhianna Morar "Mā Te Ture Anō Te Ture E Aki: Reconceptualising Sovereignty and the No-Harm Rule" (LLB (Hons) Seminar Paper, Victoria University of Wellington, 2021) at 8.

to recognise indigenous perspectives of the human relationship with nature and Māori's role as kaitiaki or guardians.[400]

In te ao Māori, the air is a taonga, a treasure derived from Ranginui, the sky father:[401]

> Māori legend tells that following the separation of Ranginui and Papatūānuku (the earth mother) their child Tawhirimatea fled with Ranginui to his new home in the sky. From there Tawhirimatea controls the wind and elements.

Degradation of air quality degrades the mauri or life-force of air as a taonga.[402] Exercising kaitiakitanga or stewardship to protect and maintain the mauri of taonga is important to Māori.[403] Mātauranga Māori reaffirms the role of Māori as environmental custodians; solidifying the way Māori operate to safeguard and ensure the health of their native landscapes.[404] Morar states: "Māori share unique genealogies with their environment which confer certain rights and obligations to care and provide for it as an ancestor".[405]

The concept of kaitiakitanga is interwoven with the concept of utu.[406] Carwyn Jones defines utu as "the principle of balance and reciprocity".[407] The concept denotes harmony within relations and "refers to reciprocal actions in a relationship aimed at maintaining balance between parties".[408] Morar states:[409]

> Climate change and biodiversity loss…disrupt the balance between humans and the environment. […] Currently, our relationship with the environment is no longer [reciprocal, and therefore,] humans should take actions aimed at restoring the balance.

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400 Rhys Jones, Hayley Bennett, Gay Keating and Alison Blaiklock, above n 60.
401 "Māori and the air" (2019) Waikato Regional Council <www.waikatoregion.govt.nz>.
402 "Māori and the air", above n 401.
403 "Māori and the air", above n 401.
404 Te-Wainuiarua Poa, above n 65.
405 Rhianna Morar "A Multi-Jurisdictional Approach to Biodiversity and Climate Change" (LLB (Hons) Seminar Paper, Victoria University of Wellington, 2021) at 13.
406 Rhianna Morar "A Multi-Jurisdictional Approach to Biodiversity and Climate Change", above n 405, at 12.
407 Carwyn Jones *New Treaty, New Tradition: Reconciling New Zealand and Māori Law* (Victoria University Press, Wellington, 2016) at 38.
408 Rhianna Morar "A Multi-Jurisdictional Approach to Biodiversity and Climate Change", above n 405, at 12.
409 At 12.

The question then raised is, does SAI geoengineering fall within the category of actions that restore the balance? With concerning efforts towards emissions mitigation,[410] some may argue SAI reflects a desirable route to safeguard and avoid the complete breakdown of the environment. As indigenous groups are the most vulnerable to climate change, SAI methods may appear like a necessary route. Māori communities have a lot at stake in the face of anthropogenic climate change. Poor responses to climate change will reinforce inequitable health, social and economic outcomes for Māori, further burdening Māori communities. SAI might be considered a viable option to restore utu. Such a view may be formed by Aotearoa indigenous voices.

Another view that may be formed is that despite SAI representing a potential techno-fix to combat the effects of climate change, it shifts the problem rather than eliminating the problem at its core. Darren King states: "The climate change challenge for Māori society is about sustainable living arrangements and development".[411] Given the concern that SAI techniques could erode emissions abatement efforts,[412] this technique may be considered unfavourable to sustainable development.

SAI raises further cultural implications that should not be so easily dismissed. Visibility of the sky is vital in Māori mythology, as stars "represent the generations that have passed into the night".[413] SAI geoengineering may obscure the visibility of the sky to some degree, depending on how it is deployed,[414] threatening Māori cultural customs and cosmology.[415] Obscured visibility of the sky caused by SAI methods would cause cultural implications for traditional Māori growing practices and customary practices such as the Māori New Year, Matariki.[416] Matariki is celebrated at the time marked by the rise of the cluster of stars, Matariki (also known as the Pleiades cluster),[417] and the sighting of the next new moon.[418] It could be contested that these considerations are not relevant in the context of "small-scale" SAI research. However,

410 IPCC "Summary for Policymakers", above n 1, at [B.1].
411 Interview with Darren King, NIWA research scientist (Carmen Parahi, Stuff, 30 November 2018).
412 Jesse L Reynolds "Solar geoengineering to reduce climate change: a review of governance proposals", above n 211, at 5.
413 "Māori and the air", above n 401.
414 Malcolm Scott, above n 292, at 10.
415 At 9.
416 Pauline Harris and others "A Review of Māori Astronomy in Aotearoa-New Zealand" (2013) 16(3) Journal of Astronomical History and Heritage 325 at 332.
417 At 330; Paul Meredith "Matariki – Te Tau Hou Māori" (19 June 2021) Te Ara – The Encyclopedia of New Zealand <www.teara.govt.nz>.
418 Ministry for Culture and Heritage "Matariki" (21 January 2021) NZ History <www.nzhistory.govt.nz>.

decision X/33 paragraph 8(w) does not define what is meant by "small-scale"; therefore, it is subject to the determination of each Party. This raises legitimate concerns for potential cultural implications.

It must be noted that one can only claim so far that SAI geoengineering is at odds with mātauranga Māori. This paper attempts only to highlight concerns that should be considered in the review. Ultimately, such a stance requires self-determination by Māori, for Māori – to best facilitate the exercise of te tino rangatiratanga.[419] Considering indigenous perspectives in the regulatory discussions over SAI and geoengineering requires further exploration.

(e) Conclusion

The high-altitude regulatory regime is an undoubtedly positive movement for SAI regulation in Aotearoa – reflecting bottom-up regulation to tackle emergent technologies such as SAI. The regime attempts to balance innovative activity and increased research with the risks associated with rapidly evolving technologies such as SAI.

The Act and regulations impose restrictions on SAI activities, but whether these are rigorous enough is questioned. These laws could be strengthened to more effectively limit SAI activities.

A prohibition on SAI in line with decision X/33 paragraph 8(w) would not deter further research. In fact, it may stimulate SAI research to allow for informed decision-making. Under this legal framework, small-scale scientific research would be made legitimate through the licencing and permit scheme of OSHAA, whilst other forms that fall outside the defined ambit would be prohibited.

This paper recommends that before making such amendments, the effect of small-scale SAI research on the relationship between nature and humanity requires further exploration. Furthermore, Aotearoa's indigenous context and the relationship between Māori and the natural environment should be meaningfully recognised. Therefore, further restrictions on "small-scale" SAI activities may be entirely plausible and justified, granted SAI's potential impacts on mātauranga Māori. However, these matters need to be considered *by* Māori.

[419] This paper in no way intends to claim that what is stated is the universal view of Māori peoples. The paper argues that these matters require consideration.

Therefore this paper does not recommend whether small-scale activities should have stricter regulations imposed but that these matters be considered on review.

3 Overall Conclusion on Domestic Regulation for SAI

In the context of Aotearoa, while no domestic law has been enacted with the express purpose of covering SAI geoengineering activities, current legal instruments may have some application. This paper has proposed the OSHAA regulatory regime may be expanded on and strengthened in future to guarantee application to SAI activities.

What remains concerning is that certain methods of SAI could potentially (theoretically) be permitted through the licensing and permit system of OSHAA. Until and if global consensus deems these activities viable, further restrictions should be considered.

It must be noted that Aotearoa can only regulate, control and prohibit activities under OSHAA within territorial boundaries. Therefore, strengthening domestic law and regulation cannot prevent risks beyond national jurisdiction. This is a considerable impediment to domestic laws' capacity to regulate activities that pose risks of transboundary harms.

VI Conclusion

SAI geoengineering is an emerging field of scientific innovation with social, ethical and cultural implications – requiring careful deliberation by policymakers. SAI activities are fraught with risks and uncertainties. With an apparent international lacuna in geoengineering governance, the regulation of SAI is left mainly to domestic laws. Aotearoa has taken significant steps in recent years to safeguard regulation for high-altitude activities conducted in airspace under the OSHAA. Given the considerable risks and implications of SAI activities, this paper considers that Aotearoa could consider taking further stricter measures to regulate SAI under OSHAA. This paper noted several methods of strengthening the law applying to high-altitude activities.

In the least, it is hoped that the ideas and issues raised in this paper will stimulate further discussion on the bottom-up approach of regulation for SAI activities and Aotearoa's role in inciting stricter legal regulation for SAI geoengineering.

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