Justice in Climate Engineering

Towards a Rawlsian Appropriation

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Declaration

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Chapter 3
The Ethics of Climate Engineering: A Review of Literature

Chapter 4
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Chapter 5
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Chapter 7
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Abbreviations

Acronym	*Definition*
CBD	*United Nations Convention on Biological Diversity*
CDR	*Carbon Dioxide Removal*
CLRTRAP	*Convention on Long-range Transboundary Air Pollution*
ENMOD	*United Nations Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques*
Hoc IUSSC	*House of Commons Innovation, Universities, Science and Skills Committee*
IMO	*International Maritime Organisation*
IPCC	*Intergovernmental Panel on Climate Change*
NAS	*National Academy of Sciences (USA)*
NOAA	*National Organic and Atmospheric Administration (USA)*
SAG	*Sulphate Aerosol Geoengineering*
SAI	*Sulphate Aerosol Injection*
SRM	*Solar Radiation Management*
UNCED	*United Nations Conference on Environment and Development*
UNEP	*United Nations Environment Programme*
UNFCCC	*United Nations Framework Convention on Climate Change*
WMO	*World Meteorological Organization*

Abstract

Justice in Climate Engineering – Towards a Rawlsian Appropriation
Augustine Thomas Pamplaniyil

Climate Engineering as a technological solution to anthropogenic climate change has been on the table at least since 2006. Understandably, there has been considerable activity among ethicists in weighing the pros and cons of climate engineering. This research approaches the climate engineering ethical debate from the point of view justice.

The lead question of this research is, can climate engineering be developed in a just manner? And the research question is answered from the perspectives of distributive justice, intergenerational justice and procedural justice. The concerns with distributive, intergenerational and procedural justice are evaluated against the theoretical framework of the notion of distributive, intergenerational and procedural justice in John Rawls. After exposing the serious challenges with climate engineering to be justified from the point of view of justice, the thesis highlights certain essential conditions that may render climate engineering justifiable from the point of view the Rawlsian distributive, procedural and intergenerational justice. A comprehensive review of the existing literature on the ethics of climate engineering in general and on distributive, intergenerational and procedural justice in particular is a component of this thesis.

The thesis is developed in seven chapters. Following the introductory chapter, the second chapter deals with the science of climate engineering. The third chapter dealing with the arguments for and against climate engineering already coined in the existing literature creates the platform for advancing the debate from the perspective of justice. The fourth, fifth and sixth chapters deal respectively with the compatibility of climate engineering from the point of view of the Rawlsian distributive, intergenerational and distributive justice. The concluding chapter revisits the research question and suggests certain directions for future research.

The study advances the debate on the ethics of climate engineering from the perspective of justice highlighting a number of unrecognized concerns and suggesting some fresh directions.

Chapter 1
Introduction

An ancient Chinese proverb says that the *yang* – one of the two polar opposites in the cyclic motion of the *Tao*, the ultimate reality of the Chinese – having reached its climax will retrieve in favour of the *yin*.[1] This proverb provides a paradoxical analogy to the changing paradigms of human interaction with nature. While the Baconian dictum, "I am come in very truth leading you to Nature with all her children to bind her to your service and make her your slave[...]"[2]commanded the attitude of exploiting and conquering the earth in the industrial age, the general mindset of the ecological thinking in the contemporary age is to safe-guard the earth by refraining from harmful human interventions. Hence the contemporary struggles with combating the dangers of climate change particularly by means of mitigation. While the technological interventions have been largely causative of the dangers of climate change, ironically, today technology itself emerges as a potential contender tocombat the dangerous climate change. A technology that is still in the offing, called climate engineering or climate engineering, with hitherto unprecedented levels and scales of planetary outreach and global impact is being debated by scientists, policy makers and ethicists as a potential candidate to address the issue of climate change.

1.1 The Climate Engineering Debate

Climate engineeringas a technological solution to anthropogenic climate changes or as a supplementary tool to mitigation and adaptation has been on the table at least since 2006 with

[1]*Tao Te Ching*, Forke (Translator) See, Joseph Needham, *Science and Civilization in China*, Vol. 2, *History of Scientific Thought* (Cambridge University Press: 1956), p. 344.

[2]Francis Bacon, *Works*, Vol. 3, eds. James Spedding, Robert Leslie Ellis, and Douglas Devon Heath, (London: Longmans Green, 1875), p. 528. A much stronger formulation of the negative philosophy of nature in Bacon is his writing in *Cogitata Visa:* "The mechanical inventions of recent years do not merely exert a gentle guidance over Nature's course, they have the power to conquer her and subdue her, to shake her to her foundations." Francis Bacon, "Thoughts and Conclusions on the Interpretation of Nature or a Science of Productive Works" (*Cogitata et Visa*) (written in 1607), in Farrington, *Philosophy of Francis Bacon* (Liverpool: Liverpool University Press, 1964), p. 93; see also pp. 96, 99. Some scholars differ on the popularly negative tone of these formulations. See for instance, Carolyn Merchant, "The Violence of Impediments - Francis Bacon and the Origins of Experimentation," *Isis* 99 (2008): 731–760; particularly note no. 50 on page 749.

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the paper by Crutzen in *Climatic Change*.[3] Today it has moved from a fringe proposal to a mainstream contender among the various solutions to the dangers of climate change. The proposal reached the centre stage with the fifth part of IPCC's (*Intergovernmental Panel on Climate Change)* series of climate change assessment reports finalised in October 2014.

Understandably, the climate engineering proposal has been generating a lot of heat from the ethical, social and political, and public terrain. Climate engineering elicited the enthusiasm and attention of ethicists and policy makers especially since the beginning of this millennium. Paul J. Crutzen in his trend-setting paper on sulphate aerosol injection (SAI) had conceded that there "are many" ethical issues in store for it.[4] Preston (2014) observes: "No previous technology has intentionally manipulated the earth at such a fundamental level, deliberately altering a system with so much complexity and promising such widespread effects. If initiated, climate engineering would take anthropogenic influence on the earth to a whole new level."[5] The overarching interdisciplinarity, the global outreach of the technology exercised in a non-encapsulated system, as well as the unprecedented levels and scales of impact and duration make the climate engineering controversy quite complex. Even Bunzl's (2009) observation that climate engineering "falls into a special class of scientific endeavours that generate a set of methodological challenges…,"[6]despite recognizing the climate engineering peculiarity does not seem to be fully freed from reductionist simplification as it reflects only the methodological complexity of the controversy. The scientific hype as well as the ethical caution about climate engineering is already reflected in some of the metaphors coined to describe climate engineering, like "a magic bullet for climate change,"[7] "emergency brake,"[8] "a brute force way,"[9] and the "Geoengineering Taboo."[10] The sharp divide already

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[3] Paul Crutzen, "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?," *Climatic Change* 77 (2006): 211-220.
[4] Crutzen 2006, p. 217.
[5] Christopher J. Preston, "The Extraordinary Ethics of Solar Radiation Management," in Christopher J. Preston, Ed., *Engineering the Climate: The Ethics of Solar Radiation Management* (Lanham: Lexington Books, 2012, Paperback Edition, 2014), p. 1 (We use the paperback edition).
[6] Martin Bunzl, "Researching Geoengineering: Should not or Could not?" *Environmental Research Letters* 4 (2009), p. 2. Available at stacks.iop.org/ERL/4/045104. Accessed on October 23, 2014.
[7] Ujjayant Chakravorty, Andrew Leach and Michel Moreaux, *Would Hotelling Kill the Electric Car?TSER Working Paper Series*, April 2010, pp. 4-5. Available at http://www.sciencedirect.com/science/article/pii/S0095069610001245. Accessed on April 14, 2014.
[8] Victor Brovkin, Vladimir Petoukhov, Martin Claussen, Eva Bauer, David Archer, Carlo Jaeger, "Geoengineering Climate by Stratospheric Sulfur Injections: Earth System Vulnerability to Technological Failure," *Climatic Change* 92:3 (2009): 243-259, p. 244.
[9] Mike Hulme, "Climate Change: Climate Engineering through Stratospheric Aerosol Injection," *Progress in Physical Geography*" 36 (2012), p. 701.
[10] Albert C. Lin, "Does Geoengineering Present a Moral Hazard," *UC Davies Legal Studies Research Paper Series*, Research Paper 312, (2012). Available at http://ssrn.com/abstract=2152131, p. 13. Accessed April 29, 2015.

established between the proponents and the opponents makes the ethical deliberations exciting and intriguing.

1.2Framing the Research Question

This research intends to appropriate the ethics of climate engineering from the perspective of justice. A landscape view of the debate setting tells us that as a form of technology that is still at the conceptual level, a general strand that is running through various streams of the arguments on climate engineering is the ethical desirability of climate engineering. Climate engineering theorists and ethicists are engaged in analysing and assessing the desirability of climate engineering from the point of view of diverse ethical concerns. Climate engineering being a pioneering technology, the ethical engagement is to some extent confined to the preliminary levels, and a detailed treatment of a particular argument stream is often absent in the debate. Accordingly, an in-depth engagement with a particular issue on the debated concerns is somewhat absent barring a few, as we will be seeing in the literature review. With a view to advancing the debate further, our research wishes to approach the debate from the perspective of a specific issue, that is, the issue of justice. Hence the preliminary formulation of our research question will be:

Is climate engineeringethically desirable from the standpoint of justice?

Here our coinage of the term climate engineering needs some justification as geoengineering is the popular coinage in the literature. Geoengineering as a modern coinage refers to climate engineering covering a wide spectrum of applications including CDR (Carbon Dioxide Removal) and SRM (Solar Radiation Management). However, in the classical and traditional sense, geoengineering refers to the geological practices like dam-building, construction of artificial islands, etc. In this thesis we will be discussing geoengineering exclusively as climate engineering and hence our preference for the term climate engineering over geoengineering throughout.

In this formulation, the adoption of the issue of justice as the focus of our research needs some justification.Firstly, as we will see in chapter three on thereview of literature, justice constitutes one of the central pillars of the climate engineering controversy. There are a considerable number of papers mentioning the issue of justice. However, justice does not seem to have been given the due attention that it deserves as the reference to justice is often a subset of another argument stream. Secondly, though there is an undisputed agreement on the adverse side-effects of the technology and the geo-physical and the socio-political implications of these side-effects[11] – a full length analysis of the implications of which for justice is still pending. Thirdly, it may not be presumptuous to observe that justice enjoys a certain degree of primacy in the climate engineering ethical debate, for the perspectives provided by the concerns with justice provide a vantage point from which to partly refute or substantiate and to prioritise some of the leading arguments for and against climate engineering.

Some further clarification on how the concept of justice employed in this thesis relates to ethics as a moral philosophy will be further helpful at this point. In moral discourse, Justice can be treated as an umbrella term referring to all ethical issues. Justice may also be treated as one moral dimension of the moral aspects in philosophy. In this thesis, the treatment of justice is more as a particular subset of moral philosophy especially in the first three chapters. This is particularly true of the chapter on review of literature as we are distinguishing between the various ethical issues in climate engineering where justice constitutes only one of the main frame arguments. However, in the normative chapters, it can be seen that justice is mostly treated as an overarching ethical principle. This general treatment of justice was necessary as we find that justice enjoys a certain degree of primacy in regard to many other ethical arguments in the context of climate engineering.

We also recognise a problem in the above formulation of our research question. It is not theoretically possible to justifya normative judgment on the desirability of climate engineering exclusively from the perspective of justice. Though justice is often an important aspect when assessing ethical desirability, it does however not seem to be a necessary condition for desirability, as it might give way to otherethical principles in the assessment of what is ethically desirable in particularsituations. Nor does it appear to be a sufficient condition for desirability. Accordingly, avoiding this problem, we reformulate the research question as follows:

Can climate engineering be developed in a manner compatible with justice?

This formulation avoids the logical error of a generalised conclusion concerningethicaldesirability based onthe analysis of anissue that is neither necessary nor sufficient for desirability. Further, as climate engineering technology is still far from taking a

[11] See Chapter 3, 3.3.2.1.1

concrete shape and form and the issue of research and development itself is strongly contended, a research question that directly targets the dynamics and procedures of the development of the technology is an imperative at this point. The above formulation is hoped to capture these dynamics of the assessment.

As the issue of justice, particularly in the context of climate change, is very complex and wide, for want of clarity and precision, we narrow down the scope of our research to three dominant subsets of justice, namely, distributive justice, intergenerational justice and procedural justice. These three aspects of justice are found to be most important and most rewarding in the case of climate engineering. As a technology that is loaded with several foreseen and unforeseen consequences, the development and deployment of climate engineering will provoke immediate and direct concerns for distributional justice. Second, as a technology, the impact of which is stretching out far into future and the future generations being the victims or beneficiaries of our development or deployment of the technology, the issue of intergenerational justice finds its natural course onto the scene. Finally, the concerns with procedures are all the more overarching with regard to normative judgements over a pioneering and largely untested technology. As a seminal technology, visualisation of the methods, and techniques of climate engineeringis still far from being complete. Procedural justice becomes one of the self-imposing choices for the ethical analysis of climate engineering from the justice point of view. Accordingly, we revise our research question as follows:

Can climate engineering be developed in a just manner compatible with distributive, intergenerational and procedural justice?

This formulation of the research question invokes a methodological issue as to which model of the distributive, intergenerational and procedural justice are we coining in assessing the compatibility of climate engineering. Conceptual and methodological integrity demands precise theoretical models and principles of justice to be applied to the question under investigation. We are using the theoretical framework of John Rawls on distributive justice, intergenerational justice and procedural justice in exploring the compatibility of climate engineering with justice. Accordingly, the final formulation of our research question will be:

Can the development of climate engineering be just compatible with the Rawlsian principles of distributive, intergenerational and procedural justice?

Our choice of John Rawls' theory as the frame for distributive justice in climate engineering is not non-contentious as there are several theories of distributive justice. However, our preference for Rawls in the context of climate engineering may be justified for the following three reasons.

1) As we will see in Chapter 4, Rawls is one of the leading theorists of egalitarian justice who has acknowledged and appropriated the differentiated distribution of resources in the society and has suggested directions towards the alignment of the same for the greater benefit of all the members of the society, especially of the most disadvantaged in the society. There is almost a universal consensus among environmental ethicists that given the present inequalities in the distribution of ecological resources and the greater vulnerability of the poorer regions of the world to the challenges of the climate change, their fate is likely to be worse off by the predicted consequences of climate change.[12] Since the context for the ethical deliberations on climate engineering is already a differentiated context, a theory that spells out the directions for justice amidst differences has an added advantage.

2) Further, climate engineering is a kind of planetary technology exercised in a non-encapsulated system with a global range of application. However, its harms and benefits would be distributed differentially among nations and regions. Therefore, a theory of distributive justice that gives due recognition to the particular context of individual nations becomes a sort of natural choice for discussing the ethics of climate engineering. The theory of justice developed by Rawls in his two books achieves this blend of the national and the international principles of distributive justice. While his *Theory of Justice*[13] was applicable mostly to individual states, *Law of Peoples*[14] focused on the principles of justice between nations. As Michael Blake and Patrick Taylor Smith (2013) have observed, Rawls' focus is not on the *global*, but exactly on *international* justice.[15]The impacts of climate engineering, though global in outreach, are to be assessed at national and international levels. This also explains why we rely more on Rawls' *Theory of Justice* over the *Law of Peoples*, where the

[12] See for example, Jochen Prantl, "Debating Geoengineering Governance: How It Matters to the Asia Pacific Region," *NTS Alert*, April (2011). Available at http://www.rsis.edu.sg/nts/HTML-Newsletter/Alert/pdf/NTS_Alert_apr_1102.pdf. Accessed June 18, 2015.
[13] John Rawls, *Theory of Justice* (Cambridge, Massachusetts: Harvard University Press: 1999, First Published in 1971).
[14] John Rawls, *Law of Peoples* (Cambridge, Massachusetts: Harvard University Press, 2000).
[15]Michael Blake and Patrick Taylor Smith, "International Distributive Justice," in *The Stanford Encyclopaedia of Philosophy* (Winter 2013 Edition), Edward N. Zalta (Ed.). Available at <http://plato.stanford.edu/archives/win2013/entries/international-justice/>. Accessed March 21, 2017.

latter work might have been the more intuitive suggestion for a discussion of distributive justice in climate engineering.[16]

3) Yet another conceptual justification for our preference to the Rawlsian egalitarianism is the idealised state of affairs of the original position envisaged by Rawls. Rawls undisputedly underscores the equality of all in accessing the primary goods of their society. Rawls' views of the primary good and the hypothetical original position are developed in the social context. The imagery of the original position shows how parties would decide on the principle of equal access in the just distribution of primary goods. Now, if we take the analogy of the original position to the natural context of accessing the natural resources, the conditions and specifications of the original position would provide the just framework for the fair allocation of the natural resources. The primary natural resources here would refer to water, precipitation, cultivable land, sunlight, etc., the accessibility to which forms some of the central issues of distributive justice in climate engineering. From an ecological point of view,[17] the present standards and practices of consuming the natural resources between nations are highly unjust and imbalanced. As we will see below, climate engineering is predicted to worsen this unjust scenario. The metaphors like 'impartial position' and 'mutually disinterested rationality' in Rawls' imaginary original position can provide a real impetus for preserving the pristine perspectives of justice in such an aggravated scenario. As Rawls himself has hoped, "… justice as fairness will seem reasonable and useful, even if not fully convincing, to a wide range of thoughtful political opinions…."[18]

Hence, our research endeavours to explore the pros and cons of climate engineeringfrom the viewpoint of distributive, intergenerational and procedural justice against the theoretical framework of John Rawls. The shift of focus from desirability to compatibility between climate engineering and justice throws open the provisions for endorsing climate engineering from the justice point of view if they are found compatible, or to denounce climate engineering from the justice point of view if they are not compatible in any manner or to explore and recommend the conditions necessary for making climate

[16] The principles of justice in *Theory of Justice*, accordingly to Rawls, were confined mostly to particular nation state. Rawls developed his theory with international applicability in his *Law of Peoples*. However, the liberal institutionalists drew more from the *Theory of Justice* for international distributive justice. See, Blake and Smith 2013.

[17] By ecology here we mean the sustainable way of living in tune with the organic interconnectedness of life, often denoted by the metaphor, web of life. We do not take ecology in a strict environmentalist sense, rather our understanding of ecology is close to the perspectives of deep ecology.

[18] Rawls, *Theory of Justice*, p. xi.

engineering compatible with justice. This is the research agenda running through the normative chapters of this thesis.

1.3Methodology and Outline of the Study

In answering the research question that we framed above, methodically, we will have to answer the following sub questions implicit in the research question:

- What is climate engineering?
- What are the Rawlsian principles of distributive, intergenerational and procedural justice?
- Accordingly, from the Rawlsian perspective, is climate engineering more an opportunity or a challenge for justice?
- What are the conditions that climate engineering has to necessarily meet in order to be compatible with the Rawlsian principles of justice?

The research is structured in such a way as warranted by the research question and its sub questions. Following the introductory chapter, we move on to a historical and technological elucidation of the science of climate engineering in the second chapter. This chapter deals with the definition, history and the different techniques of climate engineering. It is a technical platform that facilitates the course of discussion in the following chapters, particularly the normative section in chapters four, five and six.

Surveying and reviewing the argument streams for and against climate engineering coined in the existing literature provides the background from which the attempts at advancing the debate are to begin with. Hence an acquaintance with the existing literature on the ethics of climate engineeringis envisaged in the third chapter,whichreviewstheliterature on the ethics of climate engineering. Assessing the present status of the ethical evaluation of climate engineering, specifically identifying the leading arguments advocating climate engineering technologiesas well asthe scientific, social, and philosophical arguments[19] that denounce or advocateclimate engineering,is the prime objective of this chapter. Alongside dealing with the diverse dynamics of the debate this chapter also dwells on the

[19]Arguments pertaining directly to the climate engineering technologies are treated as scientific arguments. Arguments related to the social consequences of the deployment of technology are considered as social arguments and the conceptual arguments related to a dormant worldview are considered as philosophical arguments.

interdisciplinary setting of the overall debate highlighting some of the philosophical perspectives that are dormant in the arguments.

The normative section that follows spans over the next three chapters, namely, chapters four, five and six.Here we dwell in detail on three aspects of justice that we consider beingthe most challenging for the climate engineering controversy, namely, distributive justice, intergenerational justice and procedural justice.True to the common objective these chaptersfollow a similar pattern. We begin our normative analysis with a review of the current literature on the specific typeof justice under consideration in the chapter. The second part of chapters four five and sixdescribes the Rawlsian theoryon distributive, intergenerational and procedural justice respectively. The third part of each chapter in this section applies the Rawlsiantheoryto climate engineering to see if climate engineering is vindicated from the standpoint of the specific typeof justice under consideration. The fourth part is a list of recommendations consequent of the intersection between the Rawlsian principles of justice and climate engineeringin order to make climate engineering more compatible with distributive, intergenerational and procedural justice under the Rawlsian scheme. Although, the arguments in these chapters seem to go heavily against climate engineering, the suggestion from these chapters is not to reject climate engineering altogether, rather to propose the ways and means to surmount the factors that make justice and climate engineering incompatible.

Having evaluated climate engineering from the perspective of justice using the Rawlsianconception of justice, the seventh and final chapter is a retrospective and prospective reflection on the entire study. Revisiting the research question at the end of the study, this chapter summarily presents the findings emerging from the analysis. Seeing how our claims are vindicated to some extent against certain other positions, this chapter highlights certain unique aspects of this research along with suggesting fresh directions for the advancement of the overall debate whilstrecognizing the limits of this research. The final chapter is summarily the general conclusion to the research as well.

Overall we will follow an approach that will be analytically expository and dialogically hermeneutical. Our approach is primarily analytical and expository as it begins with an analysis and exposition of the issue under contention and the present state of affairs with the various dynamics of the debate on it. This approach is predominant particularly in chapter three where we make an extensive analysis of the debate scenario. The same approach is also carried through in the first part of the normative chapters where we attempt an update on the scholarship on the related areas of justice in climate engineering. A second stream of the analytical approach is in coining the theoretical framework of Rawls. We make a considerable exposition of the perspectives of Rawls from his original works on distributive, intergenerational and procedural justice. The expository approach provides a solid platform upon which to found our dialogical tools in advancing the debate from the perspective of justice. The analytical approach helps us assess the strength and weakness of the argument frames and make fresh observations and findings on the debate.

The dialogical section attemptsto intersect the theoretical framework of Rawls with the various concerns with justice in climate engineering leading to proposing newer directions, and foundational perspectives and norms. It is in this dialogue that we examine the compatibility of climate engineering and the Rawlsian views of justice. Though we encounter mostly areas of incompatibility between the Rawlsian justice and climate engineering, it does not lead us to completelyreject climate engineering, rather to hermeneutically exploring the ways and means of a possible compatibility between the two in the greater interest of justice. The potential fusion of the horizons between the theoretical frame of the Rawlsian original position and the likely scenario of justice in a post-geoengineered world empowers us with the tools for pre-eminently identifying the conditions for just climate engineering. The dialogical fusion highlights the areas of incompatibility and suggests the ways and means for addressing these incompatibilities. The recommendations made in each of the three normative chapters are the hermeneutical outcome of the dialogue between Rawls and climate engineering. The outlook section in chapter seven also carries forward the hermeneutical approach as the fusion of our justice perspectives with the emerging philosophical, scientific and epistemological perspectives is impregnated with a number of fresh conceptual directions for the debate.

1.4 Conclusion

In this introductory chapter we have been trying to situate the research in its overall perspective and structure. This chapter has elucidated the framing of the research question and the consequent methodology and approach necessary for answering the research question. It has been seen that the structure of the research is designed in such a way as to address and respond to the research question following a precise methodology. It is hoped that this introduction provides the opening pedestal to enter in to the subsequent phases of this research.

As we explained in the overall outline of the thesis givenabove, this study begins by dwelling quite a bit on the concept, history and techniques of climate engineering. Though not exhaustive, adequate acquaintance with the science of climate engineering is preliminary to carry on the research in its proposed direction. Following the opening chapter we will be moving on to the science of climate engineering in the next chapter.

Chapter 2

Concept, Historical Development and Technological Approaches of Climate Engineering

2.1 Introduction

A historical perspective on the development of climate engineering and essential clarity on the scientific fundamentals of the climate engineering techniques could be helpful for any ethical analysis of climate engineering. Hence, in this chapter, we dwell on the definition, history and the techniques of climate engineering. However, an exhaustive exposition of the entire science of climate engineering is not within the scope and limit of this research. Our introductory recourse to the science of climate engineering will focus on the clarification of scientific terminologies that would facilitate the course of discussion in the subsequent normative chapters. Accordingly, in the first part of this chapter, we present the different definitions of climate engineering as coined in the literature and try to identify the dormant perspectivities in them. In the second part, we take a short retrospection into the historical development of the climate engineering proposals from its early conceptions to the present forms. In the third and final part, we introduce the different categories of climate engineering techniques. What are the approaches and perspectivities dormant in the leading climate engineering definitions of the day? What does the history of climate engineering suggest for the contemporary appropriation of climate engineering? What is the scientific status of the various categories of climate engineering, and how relevant are their potentials and limits for the ethics of climate engineering? These are some of the lead questions that we wish to explore in this chapter. In the overall scheme of this thesis, this chapter is envisaged to be more as a scientific platform upon which the subsequent discussions are to be developed.

2.2Climate Engineering Definitions

Climate engineering refers to a set of technologies with differing goals and applications. As such, it is difficult to develop a uniform definition of climate engineering. The literature too reflects the same diversity in the framing of the climate engineering technologies. Nearly two decades ago, Thomas Schelling (1996) wrote, "'Geoengineering' is a new term, still seeking a definition. It seems to imply something global, intentional, and unnatural."[1] Though, the vagueness about the term geoengineering, as commented by Schelling, has not vanished yet, there was some considerable activity at defining it in the past two decades. Geoengineering originally was used in the geological sense, as the "science that deals with the application of geology to engineering,"[2] before it was to be coined for the efforts at combating climate change. Nowadays, it is discussed most often in the context of countervailing climate change. Some authors consider climate engineering as a subset of terraforming.[3] Given the planetary range of climate engineering as in terraforming, climate engineering is also called planetary engineering.

It is not our intention in this section to formulate a commonly accepted definition of climate engineering. Rather than a well-qualified definition of climate engineering, we find in the literature a series of descriptions of climate engineering with some common elements in them. Our discussion on the definitions of climate engineering will focus on the common strands running through these definitions, the difficulties involved in defining climate engineering and the technological and philosophical approaches dormant in the definitions.

The term geoengineering originates from the combination of the prefix "geo," originating from the Greek *ge*, that means earth, and, "engineering," with the following dictionary meaning: "The branch of science and technology concerned with the design, building, and use of engines, machines, and structures."[4] It was only in 2010 that Oxford dictionary warranted the inclusion of geoengineering.[5] As we will see in the next section, the

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[1] Thomas Schelling, "The Economic Diplomacy of Geoengineering," *Climatic Change* 33 (1996), p. 303.

[2] P. B. Gove, Ed., *Webster's Third New International Dictionary of the English Language Unabridged* (Springfield, MA: Merriam-Webster, 1986).

[3] James Rodger Fleming, *Fixing the Sky – The Checkered History of Weather and Climate Control* (New York: Columbia University Press, 2010), p. 230; David Keith, "Geoengineering the Climate: History and Prospect," *Annual Review of Energy and the Environment* 25 (2000a), pp. 245-284. Martyn J. Fogg defined terraforming as the process of "enhancing the capacity of an extraterrestrial planetary environment to support life. The ultimate in terraforming would be to create an uncontained planetary biosphere emulating all the functions of the biosphere of the Earth—one that would be fully habitable for human beings." (Martyn J. Fogg, *Terraforming: Engineering Planetary Environments* (Warrendale, Pa.: Society of Automotive Engineers, 1995), p. 9.

[4] http://www.oxforddictionaries.com/us/definition/american_english/engineering. Accessed on December 23, 2014.

[5] Rob Bellamy et al., "Appraising Geoengineering," Tyndal Centre for Climate Change Research, Working Paper 153(2012):1-36,p.6. Available at http://www.agriculturedefensecoalition.org/sites/default/files/file/new_mexico_198/198C_1_2012_Appraising_Geoengineering_Tyndall_Center_for_Climate_Change_Research_June_2012_Report_Note_Geoengineering_Definitions.pdf. Accessed on Dec. 10, 2013,; Bipartisan Policy Centre Task Force on Climate Remediation Research, "Geoengineering: A National Strategic Plan for Research on the Potential Effectiveness, Feasibility, and Consequences of Climate Remediation Technologies," (2011). Available at http://www.bipartisanpolicy.org/library/report/task-force-climate-remediation-research, p. 5. Accessed on June 3, 2014.

term has been in use long before the dictionary inclusion, and its meanings have expanded significantly over the past decade.

Table 2.1 Climate Engineering Definitions:[6]This table presents the various definitions of climate engineering in the literature with reference to its source. It covers definitions by the individual scientists as well as international organisations.

Year	**Source**	**Definition**
1992	The US National Academy of Sciences Panel on Policy Implications of Greenhouse Warming	"(L)arge-scale engineering of our environment in order to combat or counteract the effects of changes in atmospheric chemistry.'[7]
2000	David Keith	"Intentional large-scale manipulation of the environment..."[8]
2008	Stephen Barret	'[Geoengineering] is to counteract climate change by reducing the amount of solar radiation that strikes the Earth... [not] by changing the atmospheric concentration of greenhouse gases...'[9]
2009	*Urban Dictionary*	"(T)he intentional large-scale manipulation of the global environment; planetary tinkering; a subset of terraforming or planetary engineering . . . the last gasp of a dying civilisation."[10]

[6] This table has been developed relying partly on the table of geoengineering definitions in Bellamy et al. 2012, p. 5.
[7] National Academy of Sciences Panel on Policy Implications of Greenhouse Warming, *Policy Implications of Greenhouse Warming: Mitigation, Adaptation, and the Science Base* (Washington DC.: National Academy of Sciences Press, 1992), p. 433.
[8] Keith 2000a,p. 245.
[9] S. Barrett, The Incredible Economics of Geoengineering," *Environmental and Resource Economics*39 (2008), p. 45. Available at https://link.springer.com/article/10.1007%2Fs10640-007-9174-8?LI=true. Accessed March 4, 2014.
[10]*Urban Dictionary*, s.v. "geoengineering," http://www.urbandictionary.com. Accessed June 8, 2014.

2009	James Lovelock	Endorsed Urban Dictionary Definition (see above)[11]
2009	American Meteorological Society (AMS)	"(D)eliberately manipulating physical, chemical, or biological aspects of the Earth system."[12]
2009	Royal Society	'...(T)he deliberate large-scale intervention in the Earth's climate system, in order to moderate global warming...'[13]
2009	UK Government	House of Commons Innovation, Universities, Science and Skills Committee (Hoc IUSSC) endorsed Royal Society's Definition (see above).[14]
2010	IPCC	Endorsed Royal Society's Definition (see above)
2010	ETC Group[15]	"The intentional, large-scale technological manipulation of the Earth's systems, including systems related to climate."[16]
2011	Oxford English Dictionary	"The deliberate large-scale manipulation of an environmental process that affects the Earth's climate, in an attempt to counteract the effects of global warming."[17]

[11] Fleming 2010, p. 228.
[12] American Meteorological Society, AMS Policy Statement on Geoengineering the Climate System. Available at http://www.ametsoc.org/policy/2009geoengineeringclimate_amsstatement.pdf. Accessed on December18, 2016.
[13] The Royal Society, "Geoengineering the Climate: Science, Governance and Uncertainty," 2009, p. 1. www. royalsociety.org. Accessed January 4, 2013.
[14] House of Commons Innovation, Universities, Science and Skills Committee, Engineering: Turning Ideas into Reality: Government Response to the Committee's Fourth Report. 2009. Available at http://www.publications.parliament.uk/pa/cm200809/cmselect/cmdius/759/759.pdf; House of Commons Science and Technology Committee, *The Regulation of Geoengineering* (London: *The Stationary Office*, 2010). Accessed April 5, 2015.
[15] ETC Group is an Action Group on Erosion, Technology and Concentration. It works to address the socioeconomic and ecological issues surrounding new technologies that could have an impact on the world's poorest and the most vulnerable people (See, http://www.etcgroup.org/about).
[16] Pat Mooney et al., "Darken the Sky and Whiten the Earth – The Dangers of Geoengineering, What Next?" 3 (2012): 210-237, p. 216.
[17] http://www.oxforddictionaries.com/us/definition/american_english/geoengineering. Accessed June 20, 2014.

Some conditions for defining climate engineering in the modern sense were made by David Keith (2000).[18] As seen above, Keith (2000) defined climate engineering as the "Intentional large-scale manipulation of the environment..."[19] and set the components of this definition as the defining standards for climate engineering. According to Keith (2000), "For an action to be geoengineering, the environmental change must be the primary goal rather than a side effect and the intent and effect of the manipulation must be large in scale, e.g. continental to global...."[20] "Three core attributes will serve as markers of geoengineering: scale, intent, and the degree to which the action is a countervailing measure."[21] Keith (2000) contrasts climate engineering with ornamental gardening and climate changes due to fossil fuel burning. Neither ornamental gardening, nor global warming can be treated as climate engineering, for, in the case of the former, the scale is small, and in the latter, the intent of burning fossil fuels is not climate change, but energy needs, though climate change occurs as a side effect.[22]

The conditions of the definition set by Keith (2000) almost became the dominant standard in defining climate engineering as subsequent authors included those elements in their definitions of climate engineering.[23] Pat Mooney et al. (2012), in their evaluation of the climate engineering definitions have identified two additional aspects, namely, technology, and earth system, as central to climate engineering definitions along with scale and intent. For Mooney et al., climate engineering is a "high-technology approach"[24] with nothing much to do with the mitigation efforts or with changing life-styles for combating global warming. Mooney et al. also observes that the reference to the earth-system in climate engineering is potentially not limited to manipulating the carbon cycle, but it can be eventually twisted to manage the earth's hydrological cycle or nitrogen cycles.[25]

The definition of Keith (2000) has been foundational in developing the subsequent definitions by official bodies like the Royal Society (2009), IPCC (2007), and Hoc IUSSC (2009). The classical definition of Climate engineering as extensively used in present literature is provided by the Royal Society (2009), as, "...the deliberate large-scale intervention in the Earth's climate system, in order to moderate global warming....".[26] This

[18] Keith 2000a, p. 247.
[19] Keith 2000a, p. 245.
[20] Keith 2000a, p. 247.
[21] Keith 2000a, p. 247.
[22] Keith 2000a, p. 247.
[23] See, for example, Mooney et al. 2012, pp. 216-217.
[24] Mooney et al. 2012, p. 216.
[25] Mooney et al. 2012, p. 217.
[26] Royal Society 2009, p. ix.

definition was further corroborated by UK Government[27] and the Intergovernmental Panel on Climate Change. While meeting the conditions laid by Keith, this definition goes a step further with its precise climatic focus and it slightly alleviates the strong manipulative nuance in the other definitions by using a moderate term like intervention. The Royal Society and IPCC integrated the aspect of combating climate change as the professed intent of the climate engineering techniques.

In our analysis of the ethics of climate engineering, we do not subscribe to any particular definition, but go by the conventional understanding of climate engineering. We are aware that this will create some ambiguity in the ethical analysis of climate engineering. However, that is considered a just price for treating the ethics of climate engineering in general particularly as there is no consensus as to the right classification of technologies. We are also aware that all CDR technologies listed in this chapter do not necessarily fall under the climate engineering schemes. However, we follow this classification after the model of the Royal Society and the IPCC.

Although there is a consensus among various authors on the element of ‘scale’ in climate engineering definition, there is no such consensus when it comes to the element of ‘intent.’ There are arguments that intentionality and countervailing nature are no useful criteria to define climate engineering. For instance, renowned historian of science, James Fleming (2010) holds that the stated purposes of a large scale exercise like climate engineering may not be constrained to such purposes in actual exercise as it will have unintended consequences and undesirable ends.[28] It is now common knowledge that there are political factors influencing the definitions of modern technologies. Climate engineering is no exemption to it. As Mooney et al. have observed, “Defining geoengineering is a political act.”[29]

2.2.1 Prevalent Ambiguities

There are a number of problems involved in formulating a definition of climate engineering. Firstly, the term climate engineering is not accepted by all scientists to represent the various climate engineering techniques. A number of alternative terms are used in the literature to describe the same set of technologies. The alternative terms include, climate

[27] House of Commons Innovation, Universities, Science and Skills Committee 2009.
[28] Fleming 2010, p. 228.
[29] Mooney et al. 2012, p. 215.

engineering,[30] planetary engineering,[31] earth systems engineering,[32] and climate modification.[33] Bellamy et al. (2012) observe that in recent times there is an attempt at rebranding climate engineering as climate remediation as it seems to go along well with the popular terms of mitigation and adaptation.[34] It could be seen that there are mainly linguistic preferences or emphases between these terms. The varying preferences and emphases do not make an easy formulation of a uniform definition. Secondly, there is no uniform understanding about the subsets of climate engineering methods. As we will see in the third section of this chapter, there is no commonly accepted classification of the climate engineering technologies, although the general division between the SRM (Solar Radiation Management) and CDR (Carbon Dioxide Removal) is a standard practice used in the literature. Of late, there are also attempts to downplay the "emotively provocative"[35] tone of Solar Radiation Management by renaming it as "Sunlight Reflection Methods."[36] Similarly, CDR is rebranded as "Carbon Dioxide Remediation."[37] A third semantic difficulty in defining climate engineering is the synonymous coinage of climate engineering to refer solely to solar radiation management techniques.[38] As we will see in the third chapter, which contains a literature review, several papers with climate engineering in the title cover only the Solar Radiation Management (SRM) proposals ignoring the Carbon Dioxide Removal (CDR) proposals. The very definition of climate engineering given by Barret (Table 2.1) further confirms this point.

2.2.2 Remarks on the Definitions of Climate Engineering

It is clear that the need for precise definitions will become vital as the policy makers, ethicists and governments will have to make their positions on climate engineering clear in the near future. In the context of the newly speculated technologies, Mooney et al. (2012) of the ETC Group, remark that, "definitions (of geoengineering) become more complex,

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[30] For example, see, D. Bodansky, "May We Engineer the Climate?" *Climatic Change*33 (1996): 309-321.
[31] For example, M. Hoffert et al., "Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet," *Science*298 (2002): 981-987.
[32] S. Schneider, "Earth Systems Engineering and Management," *Nature*409 (2001): 417-421.
[33] R. McCormick and J. Ludwig, "Climate Modification by Atmospheric Aerosols," *Science*156 (1967): 1358-359.
[34] Bellamy et al. 2012, p. 5.
[35] Bellamy et al. 2012, p. 6.
[36] Solar Radiation Management Governance Initiative, Solar Radiation Management: The Governance of Research, 2011. Available at http://www.srmgi.org/downloads/ Accessed November 30, 2014.
[37] Climate Institute (2010), 'Conference Statement,' Asilomar International Conference on Climate Intervention, Pacific Grove, CA (USA) 22-26 March 2010. Available at http://www.climate.org/resources/climate-archives/conferences/asilomar/statement.html. Accessed March 30, 2014. See also Mooney et al. 2012, p. 217. It is observed by Mooney et al. that the scientists who gathered at Asilomar were keen to avoid the term geoengineering and the final statement of meeting did not coin geoengineering.
[38] See Barrett 2008, pp. 45-54.

contentious and consequential."[39] The definitions articulated by those who favour climate engineering evidently underscore the technological manipulation of the earth systems. The definitions of climate engineering seem to reflect an optimistic confidence in a technological solution to the problem of climate change. Going by the accepted conditions of an act being climate engineering, the message is clear that climate engineering has the direct imprint of a technical fix. Keith (2000) has been articulate in this regard, as he says, "…geoengineering implies a countervailing measure or a 'technical fix.'"[40] The terms like intervention and manipulation are loaded with technical overtones. This technical determinism in the definitions, though necessary for the independent identity of the climate engineering approach, may alienate it too much from the other approaches to combat climate change. Thus, the definitions of climate engineering seem to already invite a better clarity on the status of climate engineering in the various approaches towards combating climate change. This confusion prevalent in the literature on the status of climate engineering will be discussed in detail in the literature review in the third chapter. It is true that clarity of focus and approach is central to every definition. However, greater caution may be helpful not to narrow down the overall scope of climate engineering in dealing with a planetary problem.

Although climate engineering is contemplated in the context of the dangers of climate change, it is doubtful if the definite goal of fighting climate change has been given due importance in the definitions. The critical observation of Mooney et al. (2012) is relevant in this context: "Most definitions of geoengineering include a reference to intent (i.e., to combat climate change). But the laudable goal of combating climate change has no place in the definition of geoengineering, as it suggests that geoengineering technologies do, in fact, combat climate change."[41] The framing of the climate engineering definitions seem to be cautious, and perhaps even deceptive. Most definitions champion the cause of fighting climate change without a professed commitment to the goal and with no stated assurance of the results. It gives climate engineering, as Mooney et al. have commented, "a veneer of respectability and efficacy it has not earned."[42]

As mentioned above, the overtly scientific character of the definitions of climate engineering also seem to reflect a philosophical problematic hidden in the definitions. The present dominant definitions seem to be driven by a worldview defined by the instrumentalist and mechanical approach towards nature, dominant in the mechanical philosophy of nature of

[39] Mooney et al. 2012, p. 25.
[40] Keith 2000a, p. 247.
[41] Mooney et al. 2012, p. 216.
[42] Mooney et al. 2012, p. 216.

the 16-19th century that was also responsible for the current ecological problems. This is a point we will be discussing in detail in our philosophical assessment of the climate engineering project in the final chapter of this thesis. The technological paradigm under which the climate engineering technologies are to be branded is not without its own inherent problems. As Simon Terry has observed, climate engineering does not appreciate the notion of human stewardship of the earth, and for geoengineers, ecosystems are mere resources for the optimal benefit of the humans and therefore to be ‘fixed’ rather than to be protected or restored.[43] The highly anthropocentric definition of engineering, given by the *Encyclopaedia Britannica,* as “the application of science to the optimum conversion of the resources of nature to the uses of humankind,”[44] could be recollected in this context. As the Indian ecologist, Vandana Shiva, laments, “It’s an engineering paradigm that created the fossil fuel age that gave us climate change... Geoengineering is trying to solve the problems in the same old mind-set of controlling nature.”[45] The environmental categories of a pre-ecological age like anthropocentrism, mechanism, reductionism, and, instrumentalism seem to be the hidden frames governing the present day attempts at defining climate engineering. Understandably, the terms like “intervention,” and “manipulation” are sure to invite the displeasure of the deep ecologists – the proponents of the organic interconnectedness of life advocating particularly the metaphor, the web of life - as it does not augment well the new nuances of the nature-human relationship restored by the environmental philosophies.

2.3 History of Climate Engineering

An historical understanding might inform a richer understanding of the ethical understanding. Looking at the evolving dynamics of the present status of climate engineering proposals will give us lessons for decisions and choices about human intervention with earth systems. It has been observed in the literature that there is no comprehensive history of climate engineering existing to date.[46] Though most historical descriptions of climate engineering begin with the postwar attempts at weather and climate modifications, more

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[43] Simon Terry, “Restoring the Atmosphere: Dangerous Climate Change and the New Governance Required,” *Sustainability Councilof New Zealand* 53 (August2009). See also, Mooney et al. 2012, p. 217.

[44] Ralph D. Smith, “Engineering,” *Encyclopaedia Britannica.* available at http://www.britannica.com/EBchecked/topic/187549/engineering. Accessed March 21, 2014.

[45] ‘A Debate on Geoengineering: Vandana Shiva vs. Gwynne Dyer’ *Democracy Now* (2010), video, 8 July. Available at http://www.democracynow.org/2010/7/8/a_debate_on_geoengineering_vandana_shiva. Accessed on February 5, 2014.

[46] See, for instance, Keith 2000a, p. 249. “The historical sketch (of geoengineering) … is necessarily incomplete, and its weaknesses highlight the absence of a thorough historical treatment of deliberate climate modification.”

comprehensive discussions take the history back to the ancient mythological and imaginative dreams of controlling nature. We shall attempt a short description of the evolutionary development of climate engineering spanning over the mythological and scientific periods with a view to articulate the significance of historical perspective in the ethical deliberations on climate engineering.

2.3.1 The Mythical and Mystical Allusions

Some scholarly literature sections on the history or schemes of climate engineering carry an allusion to the metaphor of "moving the earth," attributed to Archimedes who is believed to have said in the second century BCE, "Give me a lever long enough and a place to stand, and I will move the world."[47] Given the ambitious aspirations of the climate engineering schemes, Archimedes' claim may be considered, analogically, as the most ancient metaphor of climate engineering claims. For that matter, it is not without reason that some authors take the history of climate engineering way down by millennia.[48] Analogically, climate engineering may be given a reference to the mythological and religious roots of modifying the weather and praying for a control over the climate as seen in the Greek, Roman and Indian traditions. In such mythological and religious traditions, natural gods governed the order of nature.[49] Later, it was unto science to facilitate the shift from a god-governed universe to a law-governed universe. As the case with any form of science, climate engineering too represents faith in a law-governed nature and the potential control over nature based on the knowledge of its laws.

There are anticipations of climate engineering ambitions in the literary traditions as well. Homer's *Odyssey,* Shakespeare's *Tempest,* Milton's *Paradise Lost*, and Dante's *Divine Comedy* are some literary examples bearing imaginative imprints of human intervention with nature's weather and control over nature. The megalomaniac powers of the gods and magicians over weather and climate depicted in myth and literature are now desired by engineers and futurists as reflected in the climate engineering hopes.[50] The vision embodied in such fiction thinking will have something to suggest to climate engineering, because, as

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[47] See, for instance, Fleming 2010, p. v.

[48] "… control of the elements has been in the human imagination and literature for millennia…" Stephen H. Schneider, "Geoengineering: Could We or Should We Make It Work?" *Philosophical Transactions of The Royal Society* 366 (2008), p. 3844.

[49] For example, the *Vedas*, one of the most ancient scriptures of the Hindus, dating back to around 4000 BCE, speak of the gods of rain, river, mountain, soil, and fertility.

[50] Schneider 2008, p. 3843.

Fleming (2010) comments, “myth, magic, religion, and legend are not relics of the past but constitute deep roots and living sparks of contemporary practices.”[51]

2.3.2 Early Motives – Weather Control

Fleming (2010) identifies the traces of “geoengineering” as a form of control over environment in the early practices like seeking shelter from the elements, using fire for warmth, herding animals, cultivating plants, and moving and storing fresh water.[52] For Lovelock (2009), “we became geoengineers soon after our species started using fire for cooking,”[53] and, for geoscientist William Ruddiman (2005), there was climate engineering since millennia with extensive deforestation and agriculture.[54] The seventeenth century Baconian hubris in the powers of technology was notably applied to meteorology and climatology.

Thomas Jefferson had thought of climate engineering at the beginnings of the 19th century itself. Jefferson proposed to dry marshes and clear forests to improve the American climate.[55]American meteorologist James Pollard Espy’s proposal of making rain may be treated as the first “scientific” proposal at “geoengineering.” In his *The Philosophy of Storms*, published in 1841,[56] Espy put forward a thermal theory of storm formation. Epsy claimed a connection between volcanic eruptions and rains[57] and proposed that great fire can produce rain. If a huge fireball could thrust a large amount of air to move upward in a column, it would produce a self-sustaining cloud that in turn would absorb more air and form more clouds and cause rain.[58] The proposal bestowed on him the moniker “Storm King.”[59] The American Senate turned down his proposal for its strangeness and lack of convincing scientific back up. It is commented on Epsy that “The public at large think of him (Epsy) as a

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[51] Fleming 2010, p. 10.
[52] Fleming 2010, p. 3.
[53] James Lovelock, *The Vanishing Face of Gaia: A Final Warning* (New York: Basic, 2009), p. 139.
[54] Ruddiman & F. William, *Plows, Plagues, and Petroleum: How Humans Took Control of Climate* (Princeton, N.J.: Princeton University Press, 2005).
[55] Clarence J. Glacken, *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century* (Berkeley: University of California Press, 1967), pp. 501-705; J. R. Fleming, *Historical Perspectives on Climate Change* (New York: Oxford University Press, 1998), pp.11-32.
[56] James Pollard Epsy, *The Philosophy of Storms* (Boston: Little, Brown, 1841).
[57] Earlier, Geographer Alexander von Humboldt had observed that volcanic eruptions could transform dry seasons into rainy ones.
[58] See, Fleming 2010, pp. 55ff
[59] See, T. Y. McCormick 2013. “Anthropology of an Idea Geoengineering.” Available at http://search.ebscohost.com.remote.library.dcu.ie/login.aspx?direct=true&db=bth&AN=90159324&site=ehost-live. Accessed July 18, 2016.

sort of madman, who fancies that he can produce artificial rain."[60] There were also some groups cannonading clouds to discharge rain. Epsy's rainmaking proposals were followed up by a group of artillerists and "rain fakers," who may be branded as the pluviculturalists.[61] The charlatans would mix up chemicals and dispense them from top by collecting money from poor farmers. Then there were the fog removal techniques like firing the clouds with sands, burning large amount of gasoline, and spraying calcium chloride.[62] The emerging air conditioning techniques of 1930s were a form of weather control.

Traces of climate engineering, in the sense of manipulating the carbon cycle of the earth, could be seen in the beginnings of the 20th century itself. Ironically, the initial purpose of manipulating CO_2 was not to cool the earth, rather, to warm it up! Swedish chemist Svante Arrhenius[63] and meteorologist N. Ekholm[64] are two early scientists who studied the relation between CO_2 and weather changes. Arrhenius is one of the first scientists who investigated the link between carbon dioxide levels and global temperatures. Arrhenius feared the return of the ice age. According to him the earth in future might be "visited by a new ice period that will drive us from our temperate countries into the hotter climates of Africa."[65] The solution he proposed to it was a virtuous cycle in which the burning of fossil fuels could help prevent a rapid return to the conditions of an ice age.[66]He also thought that by increasing the CO_2 emissions by fossil fuel burning, agricultural productivity could be increased.

Similarly, Ekholm also suggested the merits of increased CO_2 and its positive impacts on plant growth. Based on the works of Arrhenius, Joseph Fourier, and John Tyndall, Ekholm reached at the scientific conclusion that CO_2 is a crucial factor in the greenhouse effect. He speculated about engineering the enhancement of CO_2 emission. He thought that burning coal for a period about one millennium might be required for the rise in the global temperature due to CO_2 concentration. Interestingly, he went a step further to suggest that this process should be accelerated by burning the coal exposed in shallow seams.[67]The ambitious climate

[60]*Boston Quarterly Review.* Cited in William B. Meyer, *Americans and Their Weather* (New York: Oxford University Press, 2000), p. 87.

[61] David Starr Jordan, "The Art of Pluviculture," *Science* 62 (1925):81–82; Clark C. Spence, *The Rainmakers: American "Pluviculture" to World War II* (Lincoln: University of Nebraska Press, 1980); Fleming 2010, p. 3. Fleming categorises the pluviculturalists as "round one" in the history of "scientific weather modification." James Rodger Fleming et al., Eds., *Intimate Universality: Local and Global Themes in the History of Weather and Climate* (Sagamore Beach, Mass.: Science History Publications, 2006), p. 4.

[62] See, Fleming 2010, p. 11.

[63] S. Arrhenius, *Worlds in the Making: The Evolution of the Universe* (New York: Harper & Brothers, 1908).

[64] Nils Ekholm, "On the Variations of the Climate of the Geological and Historical Past and Their Causes," *Quarterly Journal of the Royal Meteorological Society* 27 (1901): 1-61.

[65] Arrhenius, *Worlds in the Making.* See Fleming 2010, p. 5.

[66] Fleming 2010, p. 5.

[67] Fleming 2010, p. 4.

regulation dreams are anticipated by Ekholm as he says, “It is too early to judge of how far Man might be capable of thus regulating the future climate. But already the view of such a possibility seems to me so grand that I cannot help thinking that it will afford Mankind hitherto unforeseen means of evolution.”[68]Fleming (2010) comments that Ekholm accomplished the reunification of the two timescales (the human historical and the geological) and the two agencies (anthropogenic forces and natural forces) in a new form.[69]

In a period when the carbon dioxide theory did not find favour with the scientists, British steam engineer, Stewart Callendar, reformulated this theory with more scientific data and facts. Callendar’s findings established the carbon dioxide theory of climate change in 1938.[70] Compiling various weather data, Callendar showed the increase in the earth’s temperature by 0.5^0C in the early decades of the 20th century. He also estimated the 290 parts per million concentration of carbon dioxide in the closing decades of the 19th century, and, an increase of 10 parts per million in the early decades of the 20th century that was proportionate to the amount of fossil fuel burned. Legitimately, the modern theory of the green house effect due to anthropogenic causes is called the Callendar effect.[71] Unfortunately, like Arrhenius, Callendar also viewed the rise in temperature only positively, thinking that it is helpful to humankind for more productive agriculture and for delaying the ice age. Parkinson comments that Callendar’s underestimation of the rise of CO_2 was responsible for this favorable assessment. Callendar had only projected a rise in the mean temperature of 0.39^0C from the 19th to the 21st Century. Had he anticipated the actual rise in the temperature, his assessment of the net impact of the rise in temperature would have been different.[72]

In the first half of the 20th Century, the US and the USSR were at the forefront of weather control research. In the US, the focus of climate and weather modification was on increasing the precipitation. The USSR operations reached their peak in the 1960s. The communist party of the Soviet Union listed weather modification as one of the major scientific priorities of the USSR in its 22nd Congress in 1961. In the early half of the 20th century, the USSR also concentrated significantly on climate control. The USSR established the Leningrad’s Institute of Rainmaking in 1932. Experiments with cloud seeding using

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[68] Ekholm 1901, p. 61.
[69] Fleming 2010, p. 4.
[70] G. S. Callendar, “The Artificial Production of Carbon Dioxide and its Influence on Temperature,” *The Quarterly Journal of the Royal Meteorological Society*, 64 (1938): 223–240.
[71] J. R. Fleming, *The Callendar Effect: The Life and Work of Guy Stewart Callendar (1898–1964), the Scientist Who Established the Carbon Dioxide Theory of Climate Change* (Boston: American Meteorological Society, 2007), p. xiii.
[72] Claire L. Parkinson, *Coming Climate Crisis – Consider the Past, Beware the Big Fix* (New York: Rowman and Littlefield Publishers, 2010), p. 227.

calcium chloride, dry ice, and silver iodide were carried out from 1932. An experiment held in 1960-1961 claims to have cleared the clouds over a vast area of 20000 km.[73] Unlike the US focus on weather modification, the USSR had a sustained focus on climate modification probably owing to its harsh climatic conditions.[74] Construction of reservoirs, chemical control of evaporation, and removal of the arctic ice for increased warmth were some of the ambitious plans of the climate modification projects of USSR during the 1950s and 1960s. The climate engineering models in Russia, more in the geographical sense, was represented in the writings of N. Rusin and L. Flit, who wrote in 1960, that "… if we want to improve our planet and make it more suitable for life, we must alter its climate."[75] They also cautioned that changes in climate should not be used for hostile intentions.[76]

The ambitious climate engineering schemes of Russia included diverting the rivers from the Arctic and Mediterranean to the wheat fields and to the Asian region in USSR, and creation of a 'Siberian Sea' using the waters of Caspian Sea and Aral Sea areas. Such designs for climate change, "written at the height of human technological hubris in the mid-twentieth century, certainly is filled with, if nothing else, entertaining geoengineering schemes."[77] However, as Schneider (2008) has observed, the contrast between the flowery rhetoric of climate engineering and the ecological disaster in the Aral Sea today,[78] is a lesson that "environmental degradation is associated with much less ambitious engineering projects."[79]

2.3.3 Weather Warfare

Stephan Farris's worry that "(c)limate change has the power to unsettle boundaries and shake up geopolitics, usually for the worse,"[80] may also have been caused by the history of weather control exercises. Weather has played a crucial role in defining the final fate of many battles. Understandably, militarisation of weather – the control of weather for military purpose – has been attempted in several wars from ancient days through to the Vietnam War.

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[73] G. J. F. MacDonald, "How to Wreck the Environment," in N. Calder, ed., *Unless Peace Comes: A Scientific Forecast of New Weapons*, (New York: Viking, 1968). See also, Keith 2000a, p. 250.
[74] Keith 2000a, p. 251.
[75] N. Rusin and L. Flit, *Man versus Climate* (Translated by Dorian Rottenberg) (Moscow: Peace Publishers, 1960), p. 17.
[76] Rusin & Flit 1960, p. 17.
[77] Schneider 2008, p. 3844.
[78] Schneider 2008, p. 3844.
[79] N. F. Glazovsky, *The Aral Crisis: The Origin and Possible Way Out* (Moscow: Naulca. Glazovsky, 1990). See also, Schneider 2008, p. 3844.
[80] Stephan Farris, "Ice Free," *New York Times*, July 27, 2008, MM 20.

Scientists engaged in the weather control experiments in the early decades of the 20^{th} century assumed the role of the "weather warriors"[81] by the middle of the 20^{th} century.

Meteorologists made crucial contributions to World War I as they developed principles of battlefield climatology[82] necessary for the flight of the warplanes and artillery shelling. Weather control designs were dominant in the use of meteorology for military purposes too. Prominent mathematician at Princeton, John von Neumann's overall approach is reflected in his own words: "All stable processes we shall predict. All unstable processes we shall control."[83] Vladimir K. Zworykin, at the Radio Corporation of America (RCA) Laboratory in Princeton suggested in 1945 that accurate knowledge of cloud physics would lead to effective weather control.[84] John von Neumann developed computer-modelling systems for numerical weather predictions.

However, the early signs of the growing ethical anxieties about climate control could be seen in von Neumann himself. In 1955, he described climate control as an "abnormal science," as he was much apprehensive of the potential climatic dangers and the possibility of international conflicts.[85] Harry Wexler at US Weather Bureau sent the warnings against the modern day attempts at climate control including the threat to the ozone layer. Here we find the beginnings of social and ethical concerns taking on technology even at the dawn of the modern climate engineering hopes.

In World War II, the U.S. itself is said to have trained approximately 8,000 weather officers, to furnish crucial information for bombing raids, naval task forces, and routine operations worldwide.[86] The post war scenario saw aggressive research in developing military program in weather control. The cloud-seeding techniques developed at the General Electric Corporation were the major focus of research and development in the cold war period. The era of cloud seeding began in November 1946 when an airborne test was conducted by dropping dry ice pellets into clouds over Mount Greylock. General Electric claimed that their experiments succeeded in making snowflakes. The 1947 Annual Report of General Electric read, "Further experiments in weather control led to a new knowledge which, it is believed now, will result in *inestimable* benefits for mankind."[87]

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[81] Fleming 2010,p. 165.
[82] Fleming 2010, p. 169.
[83] John Von Neumann to Zworykin, October 24, 1945, in Zworykin, Vladimir K. "Outline of Weather Proposal," (Princeton, N.J.: RCA Laboratories, October 1945). Copy in Wexler Papers, box 18. Reproduced in *History of Meteorology* 4 (2008), pp. 57–78. See, Fleming, *Fixing the Sky*, p. 193.
[84] Zworykin 1945.
[85] John von Neumann, "Can We Survive Technology?" *Fortune* (1955): 106–108.
[86] Fleming 2010, p. 169.
[87] General Electric Corporation, *56th Annual Report and Yearbook* (New York: Schenectady, 1947), p. 27.

In 1950, Langmuri, the leading scientist on cloud seeding, equated weather control with atomic power and claimed that weather control "can be as powerful a war weapon as the atom bomb."[88] Langmuri's idea was to seed the cloud with the silver iodide, water, or dry ice, which could kick off a sort of reaction within the cloud resulting in severe drought or torrential downpours and flood. These calamities, consequentially, lead to the interruptions in the movement of the enemy troops and their food supply. Cloud seeding has the additional advantage that the movement of the wind-driven clouds was unidirectional and it was easy to deny the responsibility for the same attributing it to natural causes. Several experiments with Langmuri's cloud seeding did not produce any results and said to have highlighted only the need for better knowledge about the basics of cloud physics.[89] The storm modification projects[90] through seeding wrought international accusations against the US.[91]

The USSR experiments along the line further accelerated the pace of the weather warfare in the cold war era. In 1958, Howard T. Orville, the US Presidents' weather adviser, stated: "If an unfriendly nation gets into a position to control the large-scale weather patterns before we can, the result could even be more disastrous than nuclear warfare."[92] In the subsequent decades, the cold war agenda largely governed the weather control researches too. The military intentions also contributed to fresh proposals and researches in the field.

Project Popeye and Operation Motorpool carried out by US are perhaps the most infamous episodes in the history of the weather warfare. The US air force seeded about sixty-eight cloud targets over Southern Laos with a view to increase the rainfall and prolong the monsoon, which would obstruct the movement of the Vietnamese army. St. Amand, the designer of the project, reported, "the first [cloud] we seeded grew like an atomic bomb explosion and it rained very heavily out of it and everybody was convinced with that one experiment that we'd done enough."[93] Operation Motorpool, was most secretly conducted from 1967 to 1972. The public outrage described it as the "Watergate of weather

[88] "Weather Control Called 'Weapon,'" *New York Times*, December 10 (1950), p. 68.
[89] Fleming 2010, p. 174.
[90] Project Cirrus and Project Stormfury deserve mention in this context. Project Cirrus was launched for seeding of hurricane King in 1947, which did not produce any positive result. However, the seeding of hurricane Esther in 1961 reportedly resulted in its weakening. It motivated the meteorologists to develop more aggressive designs for modifying hurricanes called the Project Stormfury, jointly conducted by the US weather bureau, the navy and the air force, from 1962 to 1983. The project was a failure as the hurricane modification hypotheses were flawed (Fleming 2010, p. 178).
[91] In 1963, Fidel Castro accused the United States for allegedly changing the course of hurricane Flora. Mexico too blamed the US describing its drought as "resulting from cloud seeding." (Fleming 2010, p. 179).
[92]Howard T. Orville, Quoted in "The Weather Weapon: New Race with the Reds," *Newsweek*, January 13 (958), p. 54.
[93] St. Amand,*The Science of Superstorms: Playing God with the Weather* (London: British Broadcasting Corporation/ Discovery Channel, 2007). Fleming, p. 180.

warfare."[94]Geoscientist Gordon J. F. MacDonald opined that one of the most crucial lessons from Vietnam weather warfare is "that one can conduct covert operations using a new technology in a democracy without the knowledge of the people."[95]

The militarisation of weather finally precipitated the formulation and enforcement of the United Nations Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) in 1978. The ENMOD in a way officially marked the end of the era of militarisation of weather. Although there were several loopholes in the formulation of the ENMOD, it put the UN on a stand and course of action against weather modification for military purposes.[96] Gradually, beginning with mid-1970s, the weather control plans were replaced with researches in CO_2-induced changes in climate. This shift was accelerated by the growing awareness of the failure of the weather control techniques, growing public dissent against the US militarisation of weather, and the growing environmental awareness.[97]

2.3.4 Controlling the Radiation Budget

In the USSR, M. Gorodsky and V. Cherenkov advanced the proposal of white particles injected in the space around the earth in the path of sunlight, something like the ring around Saturn, to generate a 12 per cent increase in solar radiation. The purpose of the Saturn like rings envisaged by them, unlike that of the present day SRM techniques, was to heat up the poles.[98] Ironically, the discussions in USSR on inadvertent whether modifications, and on the side effects of deliberate climate changes are said to be the earliest engineering proposal on cooling the climate against climate warming caused by industrial operations.[99]

Harry Wexler was the head of research at the US Weather Bureau. In 1958, he anticipated the modern ideas of tinkering with the earth's heat budget, describing the two streams of radiant energy, namely, the downward stream consisting the heat absorbed by earth, and the upward stream of infrared radiation to space from Earth's surface. In his 1962 speech, "On the Possibilities of Climate Control," he stated that "(t)he subject of weather and

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[94] McCormick 2013.
[95] Gordon James Fraser MacDonald, "Statement," in House Committee on Foreign Affairs, Subcommittee on International Organizations, *Prohibition of Weather Modification as a Weapon of War: Hearings on H.R. 28*. 94th Cong., 1st sess., 1975. Quoted in U.S. House of Representatives, *Prohibition of Weather Modification*, 5; Munk, Oreskes, and Muller, "Gordon James Fraser MacDonald."
[96] Parkinson 2010, p. 197.
[97] Keith 2000a, p. 253.
[98] Keith 2000a, p. 251.
[99] N. T. Zikeev, G. A. Doumani, *Weather Modification in the Soviet Union, 1946–1966; A Selected Annotated Bibliography* (Washington, DC: Library of Congress, Science and Technology Division, 1967). See also, Keith 2000a, p. 251.

climate control is now becoming respectable to talk about."[100] President John F. Kennedy in his address to the UN in 1961 had spoken of "cooperative efforts between all nations in weather prediction and eventually in weather control."[101] Wexler wrote: "In seeking to modify climate and weather on a grand scale it is tempting to speculate about ways to change the shape of these basic radiation curves by artificial means."[102] He proposed to do it by changing the reflectivity of the Earth. Wexler too did not stay away from sharing the "growing anxieties" on climate control, as he stated, "Man, in applying his growing energies and facilities against the power of the winds and storms, may do so with more enthusiasm than knowledge and so cause more harm than good."[103] Given the immense contributions of Wexler in this regard, the significant observation of Fleming carries the tone of a sort of historical rectification: "Remember, it was not Paul Crutzen in 2006 but Harry Wexler about fifty years before who first claimed that climate control was now 'respectable to talk about,' even if he considered it quite dangerous and undesirable."[104]

2.3.5 Recent Developments

Italian physicist, Cesare Marchetti, coined the term 'geoengineering' informally in 1970. Formally, he coined it in 1977 in *Climatic Change.*[105] The coinage of the term referred to a method for 'disposal' of atmospheric CO_2 through injection into sinking thermohaline oceanic currents. Russian climatologist, Mikhail Budyko (1974) also shared similar views on countervailing inadvertent climate changes, as he wrote, "…it becomes incumbent on us to develop a plan for climate modification that will maintain existing climatic conditions, in spite of the tendency toward a temperature increase due to man's economic activity."[106]

NASA's James Hansen's announcement in 1988 that "global warming has begun"[107] is considered the beginning of the recent engagements with global warming. Following it, United Nations Environment Program (UNEP) and World Meteorological Organization

[100] Harry Wexler, "On the Possibilities of Climate Control," 1 1962. Manuscript and notes in Wexler Papers, box 18. Cited in Fleming 2010, p. 213.
[101] John F. Kennedy's address to the UN on September 25, 1961. Available at http://blueandgreentomorrow.com/environment/on-this-day-in-1961-jfk-reveals-weather-control-plans/. Accessed June 29, 2017.
[102] Cited in Fleming 2010, p. 216.
[103] Harry Wexler, "Further Justification for the General Circulation," Research Request for FY 63. February 9 (1962). Draft in Wexler Papers, box 18, p. 1.
[104] Fleming 2010, p. 223.
[105] C. Marchetti, "On Geoengineering and the CO_2 Problem," *Climatic Change* 1 (1977): 59–68.
[106] Mikhail Ivanovitch Budyko, *Climatic Changes,* 1974 (Translated from the Russian). (Washington, D.C.: American Geophysical Union, 1977), p. 244.
[107] James Hansen, "The Tipping Point?" *New York Review of Books,* January 12 (2006). Available at http://www.nybooks.com/articles/18618. n.p. Accessed February 21, 2014.

(WMO) convened a conference and decided to reduce CO_2 emissions by 20% by 2005. The Intergovernmental Panel on Climate Change (IPCC) was established in the same year with a view to provide periodic assessments of "the scientific, technical and socioeconomic information relevant for the understanding of the risk of human-induced climate change."[108] Following the earth summit in 1992 in Rio de Janeiro, UN Framework Convention on Climate Change (UNFCCC) set the goal of stabilizing atmospheric concentrations of greenhouse gases below the dangerous levels.

In 1983, a report for the National Research Council carried the statement of Thomas Schelling, who wrote, "technologies for global cooling, perhaps by injecting the right particles into the stratosphere, perhaps by subtler means, [might] become economical during coming decades."[109] In 1984, Stanford Solomon Penner, at the University of California–San Diego, suggested that the global warming could be offset if commercial airlines are used to emit more particulates to increase the Earth's albedo. James Early at Lawrence Livermore National Laboratory revived the issue of space mirrors in 1989 when he recommended the construction of a solar shield "to offset the greenhouse effect."[110] In 1988, plans of ocean fertilization were proposed by biogeochemist John Martin. He stated: "Give me half a tanker of iron, and I'll give you an ice age," [111] In the same year companies like Climos, Planktos, GreenSea Ventures, and the Ocean Nourishment Corporation had the commercial plans for dumping iron into the ocean.

On June 15, 1991, Mount Pinatubo in Philippines erupted and it spewed molten lava over 250 square miles and threw millions of tons of ash into the atmosphere. It served as an aerosol cloud, reflecting sunlight by roughly 10 percent for nearly two years. The Pinatubo effect reduced the average global temperature by about 0.9 degrees Fahrenheit. The Pinatubo effect was a natural analogy to a scientific experiment giving interesting clues to scientists.

[108] Intergovernmental Panel on Climate Change (IPCC), "IPCC History"; Bert Bolin, *A History of the Science and Politics of Climate Change: The Role of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2007). So far, IPCC has made five such assessments in 1990, 1995, 2001, 2007 and 2014.

[109] Thomas C. Schelling, "Climatic Change: Implications for Welfare and Policy," in National Research Council, *Changing Climate: Report of the Carbon Dioxide Assessment Committee*, 449–482 (Washington, D.C.: National Academy Press, 1983), p. 469.

[110] James T. Early, "Space-Based Solar Shield to Offset Greenhouse Effect," *Journal of the British Interplanetary Society* 42 (1989): 567–569.

[111] Quote based in John H. Martin, and Steve E. Fitzwater, "Iron Deficiency Limits Phytoplankton Growth in the Northeast Pacific Subarctic," *Nature* 331 (1988): 341–343.

The 1992 National Academy of Sciences report, *Policy Implications of Greenhouse Warming: Mitigation, Adaptation, and the Science Base*, presented climate engineering as one of the cheapest options in mitigation. In 2003, the Pentagon report, titled, "An Abrupt Climate Change Scenario and Its Implications for United States National Security," recommended the government to "explore geoengineering options that control the climate."[112] The symposium organized by the Tyndall Centre for Climate Change Research in Cambridge, also ventured to "identify, debate, and evaluate"[113] the various engineering designs for containing climate change. In 2005 Hansen's warning that the "tipping point" is nearing further fuelled climate concerns. Moreover, according to James Lovelock (2006) the earth had already crossed the tipping point.[114] In 2005, in Russia, scientist Yuri Izrael, the head of the Global Climate and Ecology Institute, suggested to President Vladimir Putin designs of burning sulphur in stratosphere to fight global warming. An actual exercise in "climate engineering" was done on August 8, 2008 by China before the start of the Beijing Olympics. China fired around thousand rockets loaded with silver iodide to clear off the rain clouds over the Olympics stadium. In 2009, Klaus Lackner proposed the concept of artificial trees inhaling CO_2 from the atmosphere.[115]

In 2006, Nobel laureate Crutzen's editorial on climate engineering[116] gave serious momentum to the climate engineering proposals. Though it shared similarities to the plans of Budyko, it was framed by different environmental and policy concerns.[117] Crutzen did not consider albedo enhancement as the best option. Instead, he recommended exploring and debating sulphate aerosol injection.[118] Several conferences on climate engineering followed, including those at the American Academy of Arts and Sciences in 2007, at MIT in 2009, and the convention in Asilomar in California in 2010. In 2009, there were reports of a climate engineering field test conducted by Izrael and this team in Russia to study the passage of solar radiation through aerosol. The Novim Group report of 2009 on climate engineering

[112] Peter Schwartz and Doug Randall, "An Abrupt Climate Change Scenario and Its Implications for United States National Security," 2003. Available at http://www.environmentaldefense.org/documents/3566_AbruptClimateChange.pdf. n.p. Accessed August 23, 2014.

[113] Fleming 2010, p. 254.

[114] James Lovelock, *The Revenge of Gaia: Earth's Climate in Crisis and the Fate of Humanity* (New York: Penguin, 2006).

[115] Klaus S. Lackner, "Capture of Carbon Dioxide from Ambient Air," in *European Physical Journal, Special Topics* 176 (2009): 93–106.

[116] Crutzen 2006.

[117] Crutzen 2006.

[118] Crutzen 2006, p. 212.

discussed the possibility of firing the ozone layer with aerosols.[119] In 2009, The Royal Society of London dedicated a special issue of the *Philosophical Transactions* to discuss climate engineering.[120]In 2009, there was also the special report of the Royal Society, titled, *Geoengineering the Climate: Science, Governance, and Uncertainty.*

In October 2008, on a dissenting note, Scientific American carried an editorial, titled, "The Hidden Dangers of Geoengineering." It described climate engineering as a fringe science with serious side effects. In April 2009, U.S. President Barack Obama's science advisor, John Holdren, stated that the United States could not afford to the "luxury" of taking climate engineering "off the table."[121] He advocated looking at deliberate efforts to countervail climate change. The first attempts at a large-scale climate engineering field test was made by 'Stratospheric Particle Injection for Climate Engineering,' a British academic consortium, in 2011. Its design was to inject reflective particles into the atmosphere with the help of 20-kilometer-long hose attached to a lofted hot-air balloon. This experiment did not take off due to political and public resistance.[122]

In 2012, The National Natural Science Foundation of China included climate engineering as a scientific research priority. In the US, in 2013, the CIA and National Academy of Sciences (NAS) joined hands to fund research into various climate engineering techniques. It was found in the same year that atmospheric concentration of carbon dioxide surpassed 400 parts per million. IPCC, in its submission to the Fifth Assessment Report (AR5) of Working Group I, referred to climate engineering techniques, but "stopped short of endorsing them."[123]On April 15, 2014, IPCC released its Working Group 3, "Mitigation of Climate Change," report that is preparatory to the 5th Assessment Report to be finalized in Copenhagen, on 27-31 October, 2014. Climate geoengineering was included in all three working groups of the IPCC Assessment Report 5.

Still today, climate engineering proposals remain at the concept level with inadequate field tests, limiting the purview of experiments to computer simulations.

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119 Blackstock et al., *Climate Engineering Responses to Climate Emergencies,* Novim, 2009. Available at http://arxiv.org/ftp/arxiv/papers/0907/0907.5140.pdf. p. 47. Accessed August 23, 2016.

120 Brian Launder and J. Michael T. Thompson, eds. "Geoscale Engineering to Avert Dangerous Climate Change," Special issue, *Philosophical Transactions of the Royal Society* A 366 (2008). Available at www.ncbi.nlm.nih.gov/pubmed/18757278. Accessed June 18, 2015.

121 McCormick 2013.

122 McCormick 2013.

123 http://www.etcgroup.org/content/ipcc-ar5-geoengineering-march2014. Accessed November 30, 2014.

***Table 2.2*:** The following table presents the major anecdotes in the historical development of the climate engineering in relation to the weather control and climate change, in chronological order.

Year	***Agent***	***Description***
1841	James Pollard Epsy	The "Science" of Storm and Rainmaking
1896	Svante Arrhenius	CO_2 and temperature rise
1900	Thomas Jefferson	Speculation on weather control
1901	Ekholm	CO_2 and temperature rise
1932	USSR Rainmaking Institute	Cloud Seeding with solid CO_2
1938	Stewart Callendar	Reformulation of the CO_2 Theory
1945	John von Neumann	Developments in meteorology
1945	Vladimir K. Zworykin	Developments in meteorology
1946	General Electric Research Laboratory	Cloud Seeding Researches
1950	Langmuri	Cloud seeding and 'atom bomb' analogy
1956	General Electric Research Laboratory	Ice-crystal formation by dry ice
1950s	Irving Langmuir	Massive seeding of weather systems
1950-60	N. Rusin and L. Flit	Geological Engineering plans in USSR
1958	Howard T. Orville	Advice to US President on Military use
1958	Harry Wexler	Earth's Heat budget control plan
1960-1961	Leningrad's Institute of Rainmaking	Cloud seeding in USSR
1960	M. Gorodsky and V. Cherenkov	Proposal for Injection of particles into space
1967-72	US Military	Project Popeye and Operation Motorpool
1970	Cesare Marchetti	Informal coinage of the term "geoengineering"
1978	UN	ENMOD
1980s	L. Francis Warren	Universal System of Weather Control
1983	Thomas Schelling	Proposal for stratosphere aerosol injection
1984	Stanford Solomon Penner	Proposal for increasing earth's albedo

1988	John Martin	Plans for ocean fertilization
1988	Climos, Planktos, GreenSea Ventures, and the Ocean Nourishment Corporation	Commercial plans for ocean fertilization
1988	Klaus Lackner	Concept of 'artificial trees'
1989	James Early	Solar shield concept
1988	James Hansen's	Warning on Global Warming
1988	UN	Establishment of IPCC
1990	IPCC	First assessment report
1991		Mount Pinatubo eruption
1992	National Academy of Sciences	Recommendation of climate engineering
1992	UNCED(United Nations Conference on Environment and Development)[124]	Earth Summit in Rio de Janeiro
1992	UNFCCC	UN Framework Convention on Climate Change (UNFCCC)
1995	IPCC	Second assessment report
1997	UNCED	Kyoto Protocol
2001	IPCC	Third assessment report
2003	Pentagon	Recommendation of climate engineering
2003	Tyndall Centre for Climate Change Research	Various climate engineering designs
2005	Hansen	Warning on "tipping point"
2005	UN	Kyoto Protocol into force
2005	Yuri Izrael	Plans for stratosphere sulphur burning
2006	Paul Crutzen	Editorial in *Climatic Change*
2007	American Academy of Arts and Science	Climate engineering conference
2007	IPCC	Fourth assessment report
2008	China	Cloud firing before Olympics
2009	MIT	Climate engineering conference

[124]United Nations Conference on Environment and Development.

2009	Izrael	Climate engineering field test
2009	Novim Group	Report on Ozone firing
2009	Royal Society	Special issue of *Philosophical Transactions*
2009	Royal Society	Report on climate engineering
2009	John Holdren	Recommendation to US President
2010	Margaret Leinen, Climate Response Fund	Asilomar Climate engineering Conference
2011	British academic consortium	Proposed field test of stratospheric particle injection
2012	The National Natural Science Foundation of China	Climate engineering as a scientific research priority.
2013	CIA & NAS	Funding for climate engineering techniques
2013	National Organic and Atmospheric Administration Centre (NOAA)	CO_2 concentration said to have surpassed 400 parts per million
2013	IPCC	References to climate engineering in submission to the Fifth Assessment Report
2014	IPCC	Working Group 3 Report

2.3.6 Lessons from the History of Climate Engineering

The history of climate engineering shows that climate engineering was not always value-free, as many exponents of weather and climate engineering were keen to highlight the dangers of side effects and possibilities of misuse, or there were social and public outcries on such ventures holding the scientists more responsible. It has been seen that the resistance to engineering and weather control has been co-existent with such moves, beginning with the first proposal of rain making by Epsy. The social and ethical appropriation were well anticipated, though nominally. Scientists Harry Wexler and Stephan Farris stand tall in the history in highlighting the dormant ethical issues in the scientific research. Even as Dyson proposed aerosol injection initially, it is observed that he envisaged it only as a design to buy time for mitigation projects.[125] This should provide some norms for modern day geoengineers in discerning the status of climate engineering as a Plan A, or Plan B.[126]

Nations of the world have abandoned many weather and climate control projects as and when they proved themselves to be flawed. This historical precedence might help dispel the apprehension that research and development, including field tests, necessarily lead to deployment of climate engineering.[127] Scientific rationality does not require the extreme evidence of a doom to discern the efficacy or inefficacy of a hypothesis. Humans can easily do away with unsuccessful projects however ambitious they may be. Climate engineering history has the double-edged warning against oversimplification.

It can be seen that there were several flawed hypotheses and failed experiments in the history of climate control. It forces Fleming (2010) to coin the phrase, "the checkered history"[128] to describe the history of climate engineering. Climate science has not reached the level of fully understanding the laws and dynamics of the complex climate mechanism.[129]Fleming (2010) seems harsh on geoengineers when he assesses their projects as based on "back-of-the-envelope calculations"[130] or their "flawed anti-heroics" as "tragicomedy—or perhaps just comedy…."[131] But it speaks volumes for the required scientific maturation of the field.

The history further reflects the lack of environmental foresight. Historical far-sightedness has been missing in the history of climate engineering. Some resultsof early climate engineering were harmful to the global climate on a long term and at a larger scale. Early weather modification projects like warming the earth, removal of the Arctic ice, cultivation of the Saharan desert and the alleged detrimental impact of some of the early projects on present climate changes testify to the humbling fact that in climate sciences, the far-sightedness does not extend even a century ahead. It warrants double-checking the dangers of the historical conditioning of our present plans, and the possibility of them to be anachronistically redundant or counterproductive. The present inconclusive scientific knowledge on the processes and dynamics of the global climate may be limiting our perception of the present climate change, and, the limits of our present-day engineering technologies might be limiting our responses to the climate change. Fleming's observation that the "… the current crop of

[125] Freeman Dyson J., "Can We Control the Carbon Dioxide in the Atmosphere?" *Energy* 2 (1977): 287–291.
[126] This point is developed further in Chapter 3; 3.4.2.2.
[127]See Section 3.3.2.2
[128] Fleming 2010, p. 267
[129] See, John Reily et al., "Uncertainty and Climate Change Assessments," *Science* 20 (2001) 5529: 430-433.
[130] Fleming 2010, p. 223
[131] Fleming 2010, p. 9.

geoengineers has yet to acknowledge the checkered history of the subject"[132] does not reflect a happy state of affairs with the present assessments of climate engineering.

Further, the history of climate engineering also highlights concerns about dormant worldviews and philosophies. The invasive engagements also reflect a mindset of control and conquer.[133] We could see that "climate engineering" projects had also shared some of the perennial human quest to control. The claims of several weather "engineers" over the history have been far-fetched from real science, tantamount to science fiction, perhaps only justified by the innate quest for dominance. There seems to be some overestimation of the scientific powers by such engineers to some extent. It is likely that even if the technology is well-intentioned, unless it is properly framed, this may be misrepresented before the public. The recent trend among climate engineering scientists to avoid the use of the very term climate engineeringseems to be a rectification along similar line. History could serve as a helpful frame for a more realistic assessment of the technology. A critical reflection on the history of climate engineeringis helpful for evaluating the principles of our interaction with nature. History also shows the vulnerability of the technology to be skewed towards military intention. The commercial and military deviations seen in history can be a critical reference to the future assessment of the climate engineering proposals, especially its governance. History tells us that the arguments against climate engineering focused on the dangers of militarisation and commercialisation cannot be dismissed at the outset.

The history of climate engineering seems to be tactfully silent about the link between the early weather control attempts and the present engagement with climate change. Though climate engineering is considered popularly as a modern engineering technology, the historical analysis tells us that it constitutes the latest phase in a historical continuum. However, this continuity is not adequately reflected in the present literature. As Keith (2000) observes: "Whereas there are modern intellectual histories of climate change…, and treatments of climate and weather modification that date from the 1970s…, there is little modern analysis that explores the links between weather and climate modification and current concerns about climate change."[134] Conversely, Keith has examined the continuity between early climate modification attempts or weather control and the present day climate engineering attempts. He makes the important distinction between the two that while the

[132] Fleming 2010, p. 223.
[133] J. B. Greenberg and T.K. Park, "Political Ecology," *Journal of Political Ecology* 1 (1994): 1-12; A. Goudie, *The Human Impact on the Natural Environment*. 5th ed. (Oxford: Blackwell, 2000.); Capra, Fritjof. 1988. *The Turning Point* (London: Flamingo).
[134] Keith 2000a, pp. 249-250.

early climate modifications dealt with mitigating the natural hazards or improving the natural states, the present day climate engineering tries to mitigate the impact of the anthropogenic climate hazards.[135] Among the three defining conditions of climate engineering set by Keith, namely, scale, intent and countervailing measures, weather and climate modifications met only the first two.[136] Keith (2000) also highlights the continuities and similarities between the early weather control and present climate engineering: "The case for continuity rests on the similarity of proposed technical methods, the continuity of citations to earlier work, a similarity of debate about legal and political problems, and finally, the strong resemblance of climate and weather modification to geoengineering …"[137]

In a nutshell, an analysis of the history of climate engineering shows how a technical issue is associated with "socio-technical hybrid issues."[138] Further scientific and technological assessment of climate engineering can be done meaningfully only in its historical, political, ethical and philosophical contexts.

2.4Climate Engineering Schemes

There is an array of technologies branded under climate engineering, ranging from the down to earth planting of trees to space based giant mirrors. In addition, no territory on earth or even space seems to be spared from the range of operation of these technologies. Climate engineering technologies, collectively taken, have a literally global target area, as the range of deployment of climate engineering technique may cover forests, desert lands, roof tops, soil, polar ice, sea ice, Northern and Southern poles, equatorial regions, surface ocean, deep ocean, coastal sediments, underwater, clouds, atmosphere, stratosphere, and space.

The most popular division of climate engineering is into two broad categories, namely, Carbon Dioxide Removal (CDR) and Solar Radiation Management (SRM) techniques. This is the standard division made in the Royal Society report in 2009.[139] However, there are also other classifications followed by other authors. For example, American Meteorological Society (AMS) has a third category called "other" proposals.[140] Depending on the target area to be manipulated by particular set of technologies, there are

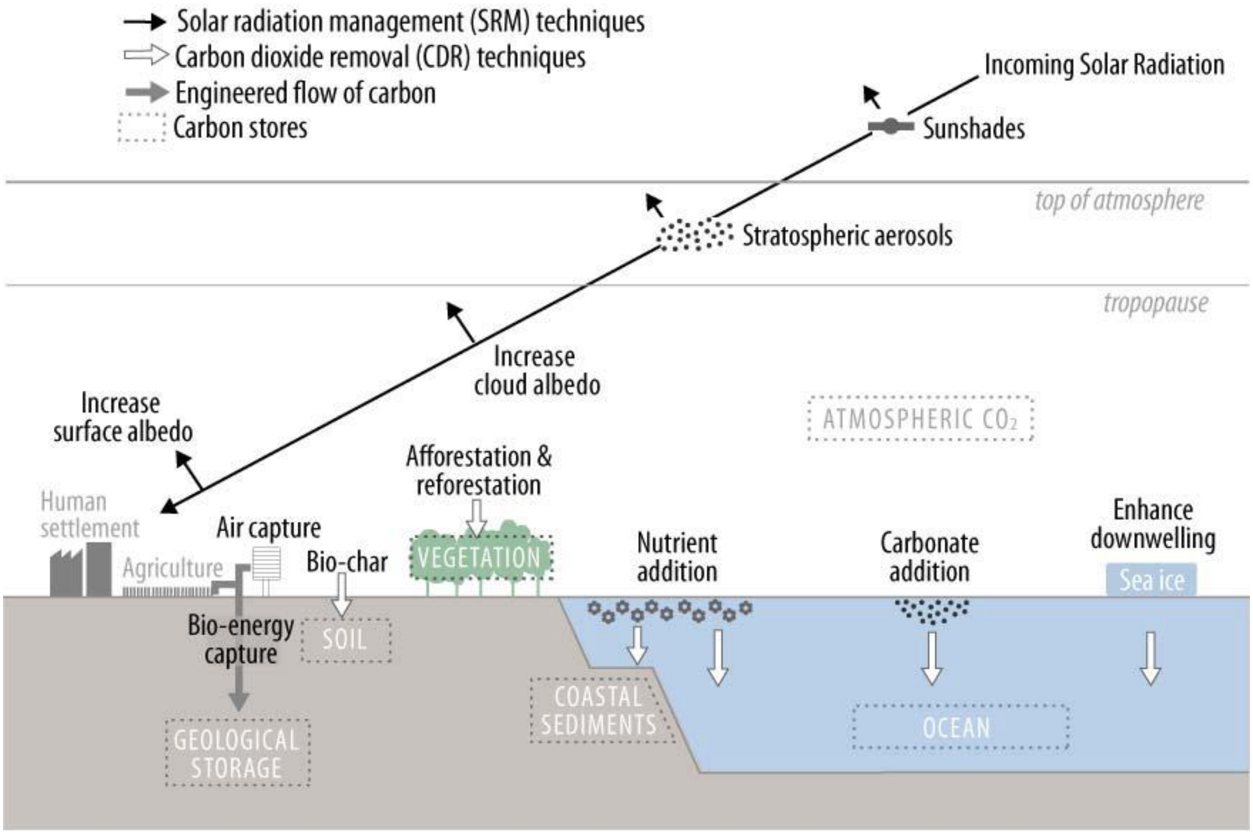
[135] Keith 2000a, p. 250.
[136] Keith 2000a, p. 250.
[137] Keith 2000a, p. 250.
[138] Fleming 2010, p. 266.
[139] Royal Society 2009, p. ix.
[140] American Meteorological Society 2009. See Bellamy et al. 2012, p. 6.

also subsets and subsets to subsets in the classification of climate engineering techniques. Yet another criterion employed is the common or territorial range of governance.[141]

Naively put, both SRM and CDR are on a 'reduction' mission. While SRM tries to reduce the solar radiation absorbed by the earth, CDR tries to reduce the carbon dioxide levels in the atmosphere. In terms of the alteration of radiative energy, SRM and CDR are also called short-wave climate engineering and long-wave climate engineering respectively, where long-wave refers to thermal radiation and short-wave to solar radiation.[142] Some say, SRM schemes "essentially put a dimmer switch on the sun."[143]

Figure 1: The following figure presents the various climate engineering options. Although this figure presents engineered flow of carbon as a separate climate engineering technology option, we treat it under the CDR techniques, as it is the dominant mode of classification in the literature.

[141] D. Humphreys, "Smoke and Mirrors: Some Reflections on the Science and Politics of Geoengineering," *Journal of Environment and Development*20 (2011): 99-120.
[142] Keith 2000a, p. 259.
[143] Andrea Thompson, Raging Debate: Should We Geoengineer Earth's Climate?*Livescience*, Feb. 10 (2010). Available at http://www.livescience.com/environment/geoengineering-earth-climate-100210.html. Accessed March 14, 2014.



Source: T. M. Lenton and N.E. Vaughan, "The Radiative Forcing Potential of Different Climate geoengineering Options," *Atmospheric Chemistry and Physics*, vol. 9,:15 (2009). Adapted by CongressionalResearch Survey (CRS).

2.4.1 CDR Methods

CDR may be subdivided into land based CDR and ocean based CDR. Both land based CDR and ocean based CDR may be divided into three subcategories, namely, physical, biological and chemical, depending on the type of intervention.[144] Following the scheme given by the Royal Society, the various CDR techniques can be organized in the following manner as in the Table below:

Table 2.3 Table of CDR Methods[145]

[144] See, Royal Society 2009, p. 9.
[145] Adapted with modification from Royal Society 2009, p. 9. As a detailed sketch of each of this method is beyond the scope of this thesis, for our short discussion, we shall be selecting only the major approaches in both categories.

	Biological	Physical	Chemical
Land Based Techniques	Afforestation and land use	Atmospheric CO_2 scrubbers ('air capture')	*In-situ* carbonation of silicates Basic minerals (incl. olivine) on soil
	Biomass/fuels with carbon sequestration	*In-situ* carbonation of silicates	
		Basic minerals (incl. olivine) on soil	
Ocean Based Techniques	Iron fertilization	Changing overturning circulation	Alkalinity enhancement (grinding, dispersing and dissolving limestone, silicates, or calcium hydroxide)
	Phosphorus/nitrogen Fertilisation		
	Enhanced upwelling		

The scientific assumption behind CDR methods is that the concentration of anthropogenic greenhouses in the atmosphere is the main reason for global warming and by removing these green house gases, especially CO_2, global warming can be contained. The removal of CDR should be to such levels as to stop global warming.[146] CDR methods, in general, collect and store CO_2 by biological, physical, or chemical means. CO_2 storing is technically CO_2 capture and sequestration. The proposed methods include afforestation, ocean fertilization, weathering of certain sedimentary rocks, or combining carbon capture and storage technology with the production of biofuels, among other approaches. We shall discuss below the leading proposals in CDR.

2.4.1.1 Carbon Capture and Sequestration

[146] Royal Society 2009, p. 9.

CO_2 is emitted both from the anthropogenic causes and naturally from earth's carbon cycle. Vegetation in its process of growth absorbs large amount of atmospheric carbon and returns most of it when they decompose. Carbon Capture and Sequestration (CCS) refers to the capturing of CO_2 emitted from anthropogenic sources.[147] Biomass, bioenergy and fossil fuel burning are the sources of CCS technologies.[148] Growth of biomass can be manipulated by land carbon sinks (on site burial in soil). Bioenergy Carbon Sequestration (BECS) is a subset of carbon sequestration. In BECS, biomass is used for creating bioenergy like hydrogen or electricity and the CO_2 produced by it is sequestered in geological formation. Biomass can be sequestered as organic material, like burying trees and the waste from crops, or by converting it to biochar.[149] Biomass could be buried also in the deep ocean. There are reports that oceans can store carbon for centuries and carbonate rocks can store carbon for thousands of years.[150]

However, its effectiveness and costs are still to be estimated. The residence period of biochar in soil is still uncertain. The question of whether it is better to 'bury or burn?' biochar is still unsettled. Besides, the requirement of large amount of energy for transporting and burying biochar is a concern. Royal Society finds the most serious concern that its processes may adversely impact growth, nutrient cycling and the viability of the ecosystems.[151] The decomposition of the organic material in the deep ocean and its return to surface is likely. Further, the absence of adequate parameters makes the cost-effectiveness assessment

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[147] See, Kelsi Bracmort and Richard K. Lattanzio, "Geoengineering: Governance and Technology Policy," *Congressional Research Service Report* (2013), p. 10. There are natural mechanisms for capturing and storing CO_2 in vegetation and Plankton, including the CO_2 from anthropogenic sources. Oceans and vegetation have natural carbon sinks.

[148] Among these three sources, fossil fuel burning is not considered as geoengineering. If only the CCS technology has biomass or bioenergy as it source, it is treated as geoengineering. Bracmort and Lattanzio observe that it is not clear why the criterion of the of the source is used for labelling CCS as geoengineering and not its outcome, that is the reduction in the amount of the CO_2 released in the atmosphere. One explanation is the fossil fuels are treated as carbon positive, while biomass and bioenergy are considered to be carbon negative. See, Bracmort and Lattanzio 2013, pp. 10-11. We are aware that biofuels and biomass production and usage are not *per se*climate engineering activities. However, they are listed under climate engineering as we are following the classification of the Royal Society.

[149] Biochar or charcoal is produced when organic matter is decomposed by heating in low oxygen environment. (For scientific details of biochar, see, CRS (Congressional Research Service) Report R40186, *Biochar: Examination of an Emerging Concept to Sequester Carbon, available at https://www.everycrsreport.com/files/20110111_R40186_1e80270dec3151cfd6d23ae44223e7cbbcc0b2e9.pdf*. For more information on agricultural practices that sequester carbon, see CRS Report RL33898, *Climate Change: The Role of the U.S. Agriculture Sector).* The decomposition of biomass, the process known as pyrolysis, can produce biochar and biofuel like syngas and bio-oil. In charcoal carbon atoms are bound together more strongly than in plant matter and thus it locks in carbon against easy decomposition for long time periods. Raw materials for biochar include wood, straw, manure, food waste, etc. Biochar in soil is said to improve agricultural productivity (Royal Society 2009, pp. 11-12).

[150] Royal Society 2009, p. 11.

[151] Royal Society 2009, p. 11.

difficult. Thus, for Royal Society, "it seems unlikely that this (BECS) will be a viable technique at any scale that could usefully reduce atmospheric carbon."[152]

Then, there is the method of capturing CO_2 from air. "Air capture is an industrial process that captures CO_2 from ambient air producing a pure CO_2 stream for use or disposal."[153] Three technological plans for air capture are, Absorption on solids, Absorption into highly alkaline solutions, and Absorption into moderately alkaline solutions with a catalyst.[154] The technical feasibility of this method is confirmed by the present commercial practices.[155] The lower presence of CO_2 in air and the cost of energy and material are problems in this approach. Cost-effectiveness is a test that it has to pass. However, Royal Society finds it to be "useful and important"[156], for, air capture plants can be located close to disposal sites like coal and oil fields, and it enables the industries to deal with "hard-to-control" carbon emissions that cannot be handled by CCS.[157]

2.4.1.2 Ocean Fertilization

Carbon cycle of the earth, in layman's language, is a give and take between land, ocean, atmosphere, vegetation and the other living organisms. Most of the CO_2 emitted to the atmosphere today will be transferred to the ocean after a period of 1000 years.[158] The algae on the surface of the ocean and the bacteria at deep sea together act as a "biological pump"[159] for the transfer of CO_2 into ocean and its re-return to the surface. The supply of nutrients in the ocean defines the process of drawing CO_2 into deep sea. Some climate engineering schemes attempt to expedite this process of transfer of atmospheric CO_2 to the ocean. Ocean fertilization is an ocean based approach in CDR. In this approach, nutrients like iron or nitrogen are added to the ocean facilitating the growth of the phytoplankton leading to the enhanced sequestration of CO_2. Phytoplankton stores the carbon in their cells in the photosynthesis process and finally sequestrates it in the deep ocean, as they die, as an organic matter. Some studies have estimated that one ton of iron can be effective in removing 30,000

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[152] Royal Society 2009, p. 11.
[153] Royal Society 2009, p. 15.
[154] Royal Society 2009, pp. 15-16.
[155] David W. Keith &Kenton Heidel and Robert Cherry, "Capturing CO_2 from the Atmosphere: Rationale and Process Design Considerations," in Brian Launder and J. Michael T. Thompson, Eds.,*Geo-Engineering Climate Change - Environmental Necessity or Pandora's Box?* (Cambridge: Cambridge University Press, 2010), pp. 107-126.
[156] Royal Society 2009, p. 16. See also, David W. Keith et al, "Climate Strategy with CO_2 Capture from the Air,"*Climatic Change* 74 (2005):17–45; Edward A. Parson, "*Reflections on Air Capture: The Political Economy of Active Intervention in the Global Environment," Climatic Change* 74 (2006): 1573–1580.
[157] Royal Society 2009, p. 16.
[158] Royal Society 2009, p. 16.
[159] Royal Society 2009, p. 17.

to 110,000 tons of atmospheric carbon.[160] By far, iron is considered to be the best nutrient for ocean fertilization.

There are several uncertainties prevailing in regard to the ecological and economic impacts of the ocean fertilization. The rate of multiplication of phytoplankton and duration of sequestration at deep sea are still unsettled issues. While the proponents argue that it enhances fish-stock, opponents lists the potential side effects like ocean acidification, further production of greenhouse gases, and hostile environment for certain ocean species due to excess of oxygen. The need for sustained and prolonged addition of iron is a further concern.[161]

2.4.1.3 Enhanced Weathering

One of the indigenous mechanisms of nature for removing the CO_2 is the disintegration or dissolution of the silicate and carbonate rocks. This is known as weathering. The silicate minerals in the rocks consume CO_2 and form carbonate. This affects the CO_2 concentration of a given region. But, this is a very slow process taking several thousand years, quite disproportionate to the rate of burning fossil fuels. The weather enhancement scheme proposes to accelerate the rate of this disintegration. Adding the silicate mineral olivine[162] to the agricultural soil is a technique proposed for this purpose.[163] This is a land based and ocean based CDR technique. This technique is based on the chemical reaction of silicate rocks with CO_2 to form solid minerals. In this reaction, one silicate molecule will consume one CO_2 molecule and carbon is stored as a solid material on land. In the ocean variant of this technique, instead of forming the solid material, the dissolved materials are released into the ocean. Compared to the land based approach, the ocean-based approach yields the double result, because, in the latter reaction, one silicate molecule consumes two CO_2. The dissolved materials can be stored only in the ocean.

The enormous mining required for the large amount of rocks, and its transportation and the additional requirements of water and energy are the related environmental threats. The scale and cost of the technique is a negative score for this proposal. Ambivalence about

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[160]Hugh Powell, 2017. "Fertilizing the Ocean with Iron: Should We Add Iron to the Sea to Help Reduce Greenhouse Gases in the Air," *Oceanus*, November 13 (2007). Available at http://www.whoi.edu/oceanus/feature/fertilizing-the-ocean-with-iron. Accessed June 23, 2017. Print edition *Oceanus* 46, 1 (January 2017). See, Bracmort and Lattanzio 2013, pp. 12-13.

[161] See Bracmort and Lattanzio 2013, p. 13.

[162] Olivine is a type of silicate rock that can increase the soil quality.

[163] R. D. Schuiling & P. Krijgsman, "Enhanced Weathering: An Effective and Cheap Tool to SequesterCO_2," *Climate Change* 74 (2006): 349–354.

the landscape to alter and the long-term impact on the quality of air and water also accompany this proposal.[164]

2.4.1.4 Oceanic Upwelling and Downwelling

Basing on the principles of the carbon cycle discussed above, another ocean based CDR proposal is the downwelling or upwelling of the ocean. Unlike the chemical manipulation of the carbon through the weathering method, in this proposal, the atmospheric carbon is transferred to the deep sea by imparting nutrients by upwelling the ocean. Upwelling here means manipulating the ocean currents. This is achieved by pumping water several hundred meters below the surface with the help of vertical pipes.[165]Similarly, the dense waters in the subpolar oceans will be downwelled.[166] It is hoped that rapid increase in the circulation will lead to speedy sequestration. The non-local impact of the exercise is the concern in this technique. An upwelling on one side of the ocean may be compensated by an upwelling on the other side of the globe, which might distort the carbon equilibrium.[167]

2.4.1.5 Afforestation

Afforestation is considered as a prime method in carbon storage.[168] It is estimated that forests can contain ten times more carbon for hundreds of years than non-forest vegetation. Therefore, afforestation aims at planting trees in landscapes that have been treeless for some time. The type of tree, climate and soil are the decisive factors in the amount of carbon stored. The estimate ranges from 2.2 to 9.5 metric tons of CO_2 per acre per year.[169] Some model recommendations included converting 60 million to 65 million acres of US agricultural land to woodlands by 2050.[170] Scientific estimation is that a minimum of 20 years is required to reap the benefit of carbon sequestration from afforestation strategies.

2.4.2 Solar Radiation Management (SRM)

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[164] See Royal Society 2009, p. 14.

[165] J. E. Lovelock & C.W. Rapley, "*Ocean Pipes Could Help the Earth to Cure Itself," Nature* 449 (2007), p. 403.

[166] S. Zhou & P. C. Flynn, "Geoengineering Downwelling Ocean Currents: A Cost Assessment," *Climatic Change* 71 (2005): 1–2, 203–220.

[167] Royal Society 2009, p. 19.

[168] Klaus Lackner's proposal of the artificial trees, as discussed in our historical overview, finds no serious mention in standard schemes of geoengineering.

[169] U.S. Environmental Protection Agency, Office of Atmospheric Programs, *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture*, EPA 430-R-05-006, Washington, DC, November 2005, Table 2-1.

[170] CRS Report R40562, *U.S. Tree Planting for Carbon Sequestration*. See, Bracmort and Lattanzio, p. 14.

The second major category of climate engineering is the Solar Radiation Management techniques. It has no recourse to mitigation or CO_2 removal in combating climate change. It addresses global warming directly by reflecting sunlight, or in other words, by enhancing the albedo or reflexivity of the earth. The scientific assumptions are simple and straightforward that the incoming radiation from the sun and the backward radiation that is held up in the atmosphere are responsible for the global warming, and therefore, combating global warming should seek to manage the long wave and short wave radiations. This is done by enhancing earth's albedo. It results in the increase in the amount of radiation reflected back to space or absorbed by atmosphere.

SRM techniques may be subdivided into stratospheric and tropospheric schemes depending on the area of applicability. The various SRM schemes, be it surface based, cloud based or space based, have the unifying strategy of reflecting the sun light. The result is that the earth's surface intake of the solar radiation is reduced. The range of operation of the various SRM schemes varies from tropospheric through stratospheric to space based plans.The studies show that space-based SRM methods would need to divert about 1.8% incoming solar radiation. For the balanced and equivalent radiative forcing effect,[171] atmosphere based or surface based methods would need to increase the albedo by about 0.31 to about 0.32.[172]

2.4.2.1 Surface Albedo Approaches

Surface albedo approaches propose to enable the earth to reflect more sunlight by increasing the brightness of the earth.[173] Individual surface albedo approaches include brightening urban area, croplands, and deserts. Painting white on rooftops, roads and pavements is a method in increasing the reflectivity of the built environment. For sunny regions, this is said to be very successful, in addition to the saving in air-conditioning.[174] Estimates have it that the albedo for roof and pavements could be increased by 0.25 and 0.15

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[171] Radiative forcing, also called climate forcing, is the "the difference of insolation (sunlight) absorbed by the Earth and energy radiated back to space…. A positive forcing (more incoming energy) warms the system, while negative forcing (more outgoing energy) cools it." Available at http://en.wikipedia.org/wiki/Radiative_forcing. Accessed March 29, 2015.

[172] Royal Society 2009, pp. 23-24.

[173] The surface albedo is the measurement of the surface brightness of the planet. It is technically defined as the proportion of the solar radiation incident on the surface that is reflected. Currently, the mean surface albedo is about 30/198 or 0.15. Engineering a radiative forcing of -4 W/m^2 in order to cool the planet, total reflection of the solar radiation by earth will have to be increased from ~107 to ~111 W/m^2. In surface albedo approaches, this is proposed to be done by increasing the solar radiation reflection from 30 to 34 W/m^2. It results in the modest increase of the surface albedo from 0.15 to about 0.17 (See, Royal Society 2009, p. 24).

[174] Royal Society 2009, p. 24.

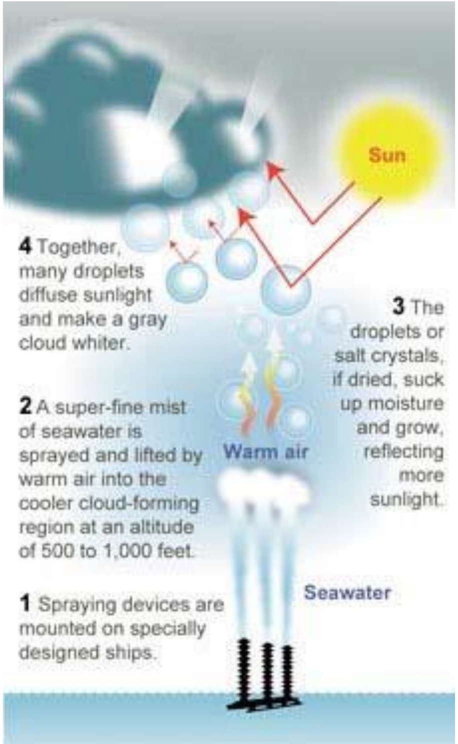
respectively, leading to a net increase in the albedo of an urban area of about 0.1.[175] Since 2% of the earth's surface is hot deserts with high incident solar radiation potential, scientists' climate engineering speculations have considered the deserts too. There are proposals to cover deserts with a reflective polyethylene-aluminium surface. It can increase the mean albedo from 0.36 to 0.8 that would provide significant radiative forcing.[176] There is an additional proposal to increase surface albedo that genetically modified plants can augment albedo.[177] It is observed that a decade or more will be necessary to prepare such plants on a commercial scale.[178]

2.4.2.2 Cloud Albedo Enhancement

Another proposal for increasing earth's albedo is cloud whitening. Cloud whitening is the process of dispersing cloud condensation nuclei, like particles of sea salt, in clouds continuously.[179] Aircrafts, ships, or seacrafts can do this. Satellites can monitor the cloud albedo. This is a method said to be stoppable at any time in case of unexpected consequences and the cloud properties shall be normal in a couple of days.[180] One study has found the West coast on North America as the most suitable area for effective cloud albedo enhancement.[181]

Figure 2: The following figure is a schematic representation of cloud whitening.

[175] H. Akbari et al, "Global Cooling: Increasing World-wide Urban Albedos to Offset CO_2," *Climatic Change* 94 (2009): 275–286.
[176] Royal Society 2009, p. 26.
[177] Andy Ridgwell et al, "Tackling Regional Climate Change by LeafAlbedo Bio-geoengineering," *Current Biology* 19 (January 27, 2009). The authors propose to genetically modify plant leaf or canopy structure to achieve greater temperature reductions.
[178] Joy S. Singarayer, Andy Ridgwell, and Peter Irvine, "Assessing the Benefits of Crop Albedo Bio-geoengineering," *Environmental Research Letters* 4 (2009): pp. 1-8. Available at http://centaur.reading.ac.uk/34557/1/1748-9326_4_4_045110.pdf. Accessed October 21, 2014.
[179] Royal Society 2009, p. 27.
[180] John Latham et al., "Global Temperature Stabilization via Controlled Albedo Enhancement of Low-level Maritime Clouds," *Philosophical Transaction of the Royal Society*, 366 (August 29, 2008): 3969-3987.
[181] John Latham et al. 2008.



Source: Oren Dorell, "Can Whiter Clouds Reduce Global Warming?," *USA Today*, June 11, 2010. Adapted by Congressional Research Survey (CRS).

2.4.2.3 Stratospheric Aerosol Injection

Aerosol injection in the stratosphere is a major proposal among SRM techniques. This technique envisages releasing huge amount of aerosols in the stratosphere in order to reflect the solar radiation. This technique has a natural example in the volcanic eruptions as in the case of Pinatubo.[182] Volcanogenic aerosols have proven the effectiveness of aerosols in global cooling. Present proposals consider sulphate aerosols, among various aerosols, to be most reliable as evidenced by the volcanic spilling of sulphate aerosols.[183] It is estimated that a 2% reduction in solar input can counter the rise in global temperature from a doubling of CO_2.[184] Several studies[185] using climate model stimulations have studied the impact of the

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[182] See Chapter 2; 2.3.5.

[183] Bracmort and Lattanzio think that future studies may recommend other particles. See Bracmort and Lattanzio 2013, p. 18.

[184] B. Govindasamy & K. Caldeira K. "Geoengineering Earth's Radiation Balance to Mitigate CO_2-Induced Climate Change," *Geophysical Research Letters* 27, 2 (2000): 141–144; B. G. Govindasamy et al, "Impact of Geoengineering Schemes on the Terrestrial Biosphere,"*Geophysical Research Letters* 29 (2002), 2061; B. Govindasamy et al, "Geoengineering Earth's Radiation Balance to Mitigate Climate Change from a Quadrupling ofCO_2," *Global Planetary Change* 37 (2003):157–168; T. M. L. Wigley, "A Combined Mitigation/Geoengineering Approach to Climate Stabilization," Science 314 (2006): 452–454; Crutzen 2006.

[185] K. Caldeira K & L. Wood, "*Global and Arctic Climate Engineering: Numerical Model Studies*," *Philosophical Transactions of the Royal Society*, A 366 (2008): 4039–4056; P. J. Rasch et al, "An Overview of Geoengineering of Climate Using Stratospheric Sulphate Aerosols,"*Philosophical Transactions of the Royal Society* A 366, (2008a): 4007–4037; P. J. Rasch, et al, "Exploring the Geoengineering of Climate Using Stratospheric Sulphate Aerosols: The Role of Particle Size," *Geophysical Research Letters* 35 (2008b), L02809;

sulphate aerosol injection. Royal Society opines that, "A general conclusion from these studies is that climate engineering with stratospheric aerosols could, in principle, be used as a means to counteract the first-order, global effects of increased greenhouse gas concentrations."[186] Aerosol injection may also prevent the melting of sea and land ice. Though it has several benefits, several serious side effects and risks are also predicted.[187]

2.4.2.4 Space Based Albedo Enhancement

It is very much a theoretical proposal in climate engineering. It is a proposal to place huge reflective shields or space mirrors in the low earth orbit[188] to reflect or deflect the incoming solar radiation. The materials proposed for this purpose are lunar glass, aluminium thread netting, metallic reflecting disks, and refracting disks. Design, size, maintenance, method of deployment, and location are the leading technical issues with regard to space based devices.[189] Space based proposals include sunlight-deflectors in near-earth orbits,[190] 55,000 mirrors - each with an area of 100 m^2 in random orbits,[191] and Saturn-like ring of dust particles with shepherding satellites.[192] It is estimated that for a 2% reduction in incoming solar radiation, dust particles to the mass of over 2 billion tones would be the measure.[193]

The logistical requirements for this project are enormous and Royal Society thinks that it would take decades for this technique to be developed. Royal Society's conclusive judgment on space-based techniques is that owing to the great uncertainties in costs, effectiveness, risks and timescales, "… they are not realistic potential contributors to short-term, temporary measures for avoiding dangerous climate change."[194] However, the society also thinks that in case of an emergency, "… it is quite possible that the best examples of this

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Alan Robock, "Regional Climate Responses to Geoengineering with Tropical and Arctic SO2 Injections," *Journal of Geophysical Research* 113 (2008a), D16101.

[186] Royal Society 2009, p. 31.

[187] Alan Robock et al., "Benefits, Risks, and Costs of Stratospheric Geoengineering," *Geophysical Research Letters* 36 (2009).

[188] Another proposal for the location of placing the shields is the L1 point. This is the distance of 1.5 million km from the earth to the sun. At this point, the gravitational attraction of sun and earth are equal. L1 point has additional advantages over the low earth orbit. See Royal Society 2009, p. 32.

[189] Royal Society 2009, pp. 32-33.

[190] C. R. McInnes, "Minimum Mass Solar Shield for Terrestrial Climate Control,"*Journal of the British Interplanetary Society* 55 (2002): 307–311.

[191] US National Academy of Sciences, "Policy Implications of Greenhouse Warming: Mitigation, Adaptation, and the Science Base,"Panel on Policy Implications of Greenhouse Warming (Washington DC.: National Academy Press, 1992).

[192] M. Mautner, "A Space-based Solar Screen Against Climate Warming,"*Journal of the British Interplanetary Society* 44 (1991): 135–138.

[193] Royal Society 2009, p. 32.

[194] Royal Society 2009, p. 33.

type may offer a cheaper and less risky approach to SRM than any of the stratospheric or near-Earth techniques."[195]

SRM methods are considered fast and cost-effective compared to the CDR methods. Climate systems are likely to return to their pre-industrial states within a few years if SRM techniques are deployed.[196] However, major risks, side effects and uncertainties are at stake in SRM methods. The likelihood of sudden termination is a major problem in SRM techniques. The impact on global and regional climate varies from proposal to proposal in SRM, like changes in precipitation pattern and ozone depletion. Undesirable changes to the regional weather pattern are attributed to SRM. The possibility of changing the chemical composition of the stratosphere, which is an important parameter of climate change along with radiation budget, is also predicted. By reducing the ultra violet rays reaching the atmosphere, SRM may extend the life-term of non-CO_2 greenhouse gases that are more potent.[197] There is also the impact on ecosystems like reduced plant respiration. By ignoring the CO_2 concentration, SRM techniques may create unknown environmental conditions with negative impacts for biological systems.[198]

2.5 Conclusion

In the first part of this chapter, we discussed the etymology and various definitions of climate engineering and the dormant worldviews inherent in them. We found that there is no uniform definition of climate engineering accepted by scholars and there are several ambiguities prevalent in defining climate engineering. The term climate engineering is not accepted by all scientists to represent the various climate engineering techniques. The second part placed climate engineering in its historical perspective. Although climate engineering is considered popularly as a modern engineering technology, our historical analysis showed that that it constituted the most recent phases in a historical continuum. The historical analysis prepares a better platform for appropriating the ethical issues in climate engineering. The third part presented a short scientific and descriptive sketch of the various climate engineering schemes. The carbon dioxide removal methods and the solar radiation management schemes with their own sub-categories caught our attention in this section. The germinal phase of the technology has been true of both these technologies.

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[195] Royal Society 2009, p. 33.
[196] See, H. D. Matthews & Ken Caldeira, "Transient Climate-carbon Simulations of Planetary Geoengineering,"Proceedings of the National Academy of Sciences 104 (2007): 9949–9954.
[197] Bracmort and Lattanzio 2013, p. 16.
[198]Royal Society 2009, p. 34.

In general, this chapter prepared the historical and scientific background for our normative chapters on the ethics of climate engineering. As the focus of our research is on the ethical analysis of climate engineering from the point of view of justice, it is necessary to familiarize ourselves with the present debate scenario on the ethics of climate engineering. A general overview of the ethical debate on climate engineering is a structural prelude to the systematic analysis of the concerns with justice in particular. Accordingly, in sequence to the present chapter on the very concept of climate engineering we will be dwelling at some length on the present debate scenario by a literature review in the following chapter.

Chapter 3

The Ethics of Climate Engineering: A Review of Literature

3.1 Introduction

The arguments for and against climate engineering already coined in the existing literature provide the primary platforms upon which the attempts at advancing the debate is to begin with and hence an acquaintance with the existing literature on the ethics of climate engineering is envisaged in this chapter. What is the present status of the ethical assessment of climate engineering? What are the leading arguments advocating the desirability of the climate engineering technologies? What are the arguments – scientific, social, philosophical – that consider climate engineering to be ethically undesirable? What are the ethical and philosophical concerns to be further appropriated for a balanced advancement of the climate engineering debate? These are some of the lead questions that we would address in this chapter. With this end in view, this chapter is reserved for a review of the literature on the ethics of climate engineering. The search methodology for identifying the related literature is explained first. The results section then organizes the various arguments for and against climate engineering as discussed in the literature. The various dynamics of the overall debate landscape like the academic, scientific and regional distribution of the debate, the interdisciplinary setting of the overall debate, the dormant philosophical perspectivities in the arguments and the arguments that are overweighed or underdeveloped are the major focus of the discussion section.

3.2 Methodology

Two searches were done on Google Scholar on December 10 and 15, 2013. They covered academic literature as well as grey literature including peer-reviewed articles, magazine articles, news reports, conference papers, books, and book chapters. When different editions of the same paper were listed as journal article, online paper or conference presentation, priority was set for the peer-reviewed journal article in the selection process.

First Search: In the first search, searches were held with primary and secondary search words. The primary search words were “geoengineering” and its synonymous usages in the academic literature such as, “climate engineering”, and “planetary engineering.” They were used as the primary search words because they represented the focal theme of the research. The literature also focuses on two subunits of climate engineering, namely, "Solar Radiation Management" and "Carbon Dioxide Removal." Accordingly, these expressions were also used as primary search words.

The secondary search words are combination search words used along with primary search words. The main combination word is "ethics" and its variations, namely, "ethical", "ethically", and "ethicists". Terms that are semantically close to "ethics" such as "moral", "morality" and "value" are also included as combination words. These secondary search words were used as they reflected the focus of this research. In addition, specific terms such as "cost-benefit," "governance", "justice", "equity", "social", "societal", "uncertainty", "risk" and "harm" are also selected as secondary search words in combination with the primary search words for their specific importance in the discussion on the ethics of climate engineering as reflected in the literature.

In the first search, distinct searches were made along all combinations as listed in Table 1. The searches produced 160 hits altogether. Out of these 160 results, 40 citations and 33 overlapping entries were excluded. Due to the variety of secondary search words, which are semantically close, understandably, there was the overlap of papers for various combinations of search. Overlapping papers were excluded from selection. Some combinations did not produce any result. Care was taken to include only those papers dealing with the ethical aspects of climate engineering. This was done by skimming through the abstract of the papers from the first set of general selection based on the search words checking if the document focused on the ethics of climate engineering. The abstract of each of the remaining 87 papers was skimmed through to ensure that the documents really focused on the ethics of climate engineering. This resulted in the elimination of three more references. As a norm, books on the ethics of climate engineering were selected in the first and second searches if only both the primary search words and their variations figured in the title of the book. This was to ensure that the focus of the book is directly on the ethics of climate engineering. Thus four books that did not meet this criterion were excluded. Thus, out of the 160 results 80 references were selected in the first search.

Table 1: First search

Primary Search Words	**Secondary Search Words**
• Geoengineering • Climate Engineering • Planetary Engineering • Solar Radiation Management • Carbon Dioxide Removal	• Ethics • Ethical • Ethically • Moral • Morality • Value • Uncertainty • Justice • Equity • Cost-benefit • Governance • Social • Society • Societal • Harm

Table 2: Results from the first search

Primary Search Word	Secondary Search Words													
	Ethics	Ethical	Ethically	Moral	Morality	Value	Uncertainty	Equity	Justice	Cost-Be	GoverNa	Social	SocieTa	Harm

										nefi t	nc e		l	
Geoengi neering	14	6	2	2	0	0	5	1	1	1	20	3	1	3
Climate Enginee ring	2	4	0	0	0	0	0	0	0	1	6	1	1	0
Solar Radiatio n Manage ment	1	0	0	0	0	0	0	0	0	0	4	1	0	0
Carbon Dioxide Remova l	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Planetar y Enginee ring	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Second search: In the first search, all the primary search words were combined with all the secondary search words in so far as they all occurred in the title. However, climate engineering being an emerging field and the focus of the research, ethics of climate engineering, being a very special area, this first search did not produce an adequate number of results for a comprehensive review. This prompted for a second search on the same database, Google Scholar.

While the first search concentrated exclusively on the title of the articles, the second search focused on the title, abstract, and keywords of the article, manually looking for the primary search word in the title of the article and the secondary search words in the abstract and keywords of the article. In the second search, the concept of abstract, where the secondary search words figure in, was understood in a broad sense. It included the abstracts of peer-reviewed papers, the introduction to grey articles, which have no specific abstract, or the opening paragraph of the magazine papers, book-reviews, news reports, and conference papers.

In the second search, the primary search word was restricted exclusively to ‘geoengineering.’ The synonymous usages of the primary search word, namely, Climate Engineering, Solar Radiation Management, Carbon Dioxide Removal, and Planetary Engineering, were skipped in the second search. This exclusion was forced by the vast number of results (870) produced by the second search with geoengineering as the primary search word. As the range of the second search included the keywords and abstract too, to keep the research focused precisely to the ethics of climate engineering, it deemed necessary to limit the number of combination words too in the second search. The restriction imposed on the primary search words is paralleled by a similar restriction on the combination words too. To keep the review precisely to the ethics of climate engineering, the combination words were restricted to “ethics” and its directly synonymous usages. Therefore, the secondary search words used for the second search are “ethics”, “ethically”, “ethical”, “moral”, “morality” and “value”. In other words, the terms pertaining to the sub-sets of ethics used in the first search, such as equity, justice, cost-benefit, social, societal, society, harm, uncertainty, and governance were excluded from the second search. However, the inclusion of these sub-sets of ethics as combination words in the first search could be justified, as it constituted the major focus or one of the major strands of discussion in the concerned articles, as suggested by their appearance in the title itself.

Accordingly, Google Scholar was searched for all the papers carrying geoengineering in the title. Each entry in the list of 870 results produced by the search was manually checked for the combination words such as ethics, ethically, ethicists, moral, morality, and value in the abstract or keywords of the article. As in the first search, care was taken in the second search too, to include only those papers treating the combination words in their ethical sense. This was done by skimming through the abstract of the papers from the first set of general selection based on the search words checking if the document focused on the ethics of climate engineering. All the papers overlapping with the first search were discounted in the second search.

The second search had ‘geoengineering’ as the only primary search word, with restricted combinations as justified in the methodology. The search with geoengineering in the title produced 870 results. 51 of these hits were found to be overlapping with the selections in the first search and they were skipped. The remaining 819 hits were individually skimmed through and each hit was checked for any of the combination words of ‘ethics’, ‘ethical’, ‘ethically’, ‘moral’ and value in the abstract, or keywords. According to the search, 10 papers were found with ethics in the abstract or keyword and 9 and 1 respectively for ethical and ethically. According to the search, three papers included ‘moral’ in the abstract or keyword while ‘morality’ found no inclusion. The combination word ‘value’ also figured in the abstract or keyword of two of the results. A total of 25 references met the inclusion criteria in the second search.

Table 3: Second search

(Primary Search Word in the Title and Secondary search words in the Abstract or Keywords)

Primary Search word	**Combination Words**
Geoengineering	Ethics Ethical Ethically Moral Morality Value

Table 4: Results from second search

Primary Search Word	**Combinations**					
	Ethics	**Ethical**	**Ethically**	**Moral**	**Morality**	**Value**
Geoengineering	10	9	1	3	0	2

Snowballing: A careful examination of the set of documents yielded from the first and second searches showed that it still did not include some of the important papers, which are significantly used in the discussion on the ethics of climate engineering. Therefore, a further search strategy relied on the snowballing method to add a number of necessary references to the results of the first and second searches. In this method, the bibliography of the documents resulting from the two searches was checked through. The papers extensively used by those authors including the reports of various formal bodies on climate engineering, which are of a canonical nature, were also added to the select entries. Thus further papers, discussing the ethics of climate engineering but excluded from the first and second searches, were included by employing the snowballing method. Employing the snowballing method, as justified in the methodology, an additional 33 references were selected. It took the total tally to 138.In summary, the searches resulted in 80 documents from the first search, 25 additional sources from the second search and 33 further references by snowballing, amounting to a total of 138 references.

3.3 Results

The debate on the ethical desirability of climate engineering is complex with cross-cutting sets of dialectics, along with many prevalent uncertainties and ambiguities. This is evidenced by the intriguing fabric of the plethora of arguments and the multiple perspectives they are interpretatively drawn into. The results of the literature review present these argument positions in a sketchy manner.Table 5 presents the distribution of the select literature according to their type, with the journal articles topping the list.[1]

Table 5: Type of References

1	Journal Articles	62
2	Online Papers	28
3	Magazine Articles	14
7	Books	12
4	Book Chapters	10
5	Reports	5
6	Conference Papers	5
8	Encyclopaedic Entries	2
	Total	**138**

[1]The Journal articles here refer to the papers published in peer-reviewed journals with some focus on a specific academic area. Online Papers mean the research papers and draft of the papers to be published and other materials that are available in online journals or as online material. Magazine Articles refer to the papers published in periodicals, print or online, with a more popular appeal and vast variety of scientific, social and cultural focus. Renowned periodicals like *Nature* and *Science* are treated under the Magazines in this classification.

Long before the science of climate engineering was to gain momentum, in 1996, Jamieson and Schneider had addressed the question of whether to engage in extensive research into the feasibility of the various potential climate engineering strategies and had responded in the affirmative. The following decade saw just 3 more papers published on the ethics of climate engineering. The relatively large number of publications in the recent three years shows that the attention towards climate engineering is on the rise. Table 6 presents the chronological development of the debate from 1996 to 2013. The table shows the nominal beginnings of climate engineering in the second half of the 1990s, the declining attention in the first half of the first decade of 2000 and the sudden uprise of interest in the latter half.

Table 6: Chronological Range of Publications

1996	1
1997	0
1998	2
1999	0
2000	1
2001	0
2002	0
2003	0
2004	0
2005	0
2006	6
2007	4
2008	6
2009	14
2010	29
2011	17
2012	35
2013[2]	23
Total	**138**

[2] This review covers only the papers available on Google Scholar till December 15, 2013. A quick update on the preliminary search until 2017 was tried in August 2017. The search with geoengineering and ethics and climate engineering and ethics as the search words has produced 7 more papers between 2014 and 2017. Solar Radiation Management and Ethics produced one more result. Carbon Dioxide Removal and Ethics did not produce any results.As this review is based on the Google Scholar, it includes only those papers published in English. It implies that some of the observations made on the literature review in regard to the academic lopsidedness, and the North-South and West-East allusions are only provisional as the review does not include the papers published in other languages.

There is an increasing rise in the attention on climate engineering as testified by the steady rise in the number of publications in the field. Nerlich and Jaspal (2012) had argued that the debate shows the likelihood of a closing down.[3] Their argument has been more speculative than statistical. Our statistics shows that over the past decade, 2012 and 2013 have the largest number of publications and it shows that the debate has been gaining momentum and slowly building up along the social and moral lines too. Scholte et al. (2013) who apprised the framing of the debate in the newspapers also would agree with us on this observation: "We wish to confront the notion that the debate on geoengineering may be closing down over time: indeed in scientific literature one can see more publications about the sociopolitical implications, as well as ethical dimensions, which were lacking before… These developments suggest that over time the debate may be opening up to more voices."[4]

The present ethical responses to such a crucial and global problem seem to be unevenly balanced. 95% of the authors are from the British, American and European setting.[5] The voice of Asia, Africa and South America are not adequately represented on the scene. This calls for more extensive engagement with justice concerns, overlooking of side effects, governance issues and risk assessment. A contextually bound appraisal of a technology with a trans-boundary impact might be tantamount to a procedural impropriety.

The papers published in the initial phase of the debate are found to be more inclined to favour climate engineering. However, there is a gradual shift towards more cautionary and conditional endorsement. As the debate gets diversified over time and more and more information is poured in, there seems to be a concurrent dynamics of maturation for the ethical deliberations too.

Issue-specific discussion treating the sub-points and issues of a major argument under contention is not adequately found in the literature. Barring a few articles dealing with a specific ethical issue to advanced levels, many papers are a hotchpotch of ethical, cultural,

[3] B. Nerlich and R. Jaspal, "Metaphors We Die by? Geoengineering, Metaphors and the Argument from Catastrophe," *Metaphor and Symbol* 27 (2012): 131–147. See also, Scholte et al. 2013, "Opening up the Societal Debate on Climate Engineering: How Newspaper Frames are Changing," *Journal of Integrative Environmental Sciences* 10 (2013), p. 5.

[4] Scholte et al. 2013, p. 5.

[5] See, Bidisha Banerjee, "The Limitations of Geoengineering: Governance in a World of Uncertainty," *Stanford Journal of Law, Science and Policy*, May (2011), p. 23. "[T]he proponents of geoengineering governance, at present, hail from the U.S., Canada, Europe, the U.K., and Australia. Additionally, a handful of elite developing country scientists from the Academy of Sciences for the Developing World are involved in an SRM governance initiative with the Royal Society…. The technologies of humility rubric, which emphasizes both vulnerability and distribution, would suggest that there is a need to create processes that can fruitfully involve developing-world citizens in deliberative dialogue with policy-makers and scientists early in the process of designing region-scale geoengineering interventions." It is not overlooked that Indian scientists are involved in US Project (See, Bracmort and Lattanzio 2013, p. 3. Footnote no. 10).

political and governance issues in general engaging themselves in no serious analysis. Most articles do not dwell at any significant length on a specific, scientific, social, political or ethical problem. This lack of focus in debate is possibly due to the early phase of the debate.

A random reading of the various papers generates the immediate impression that climate engineering debate cannot be confined to the domains of climate sciences, but it has explicit interdisciplinary ramifications covering the social, political, and philosophical domains as well. Given the complexity of the debate with such disciplinary interdependence, a systematic organisation of the various arguments is not likely to be that straightforward, but open to arbitrary schemes to a significant extent. However, in our scheme, we take a rather straightforward approach by primarily separating the seemingly *for* and *against* arguments.[6] The various arguments for climate engineering are organized under six main frames with a number of sub-frames. Accordingly, the cluster of arguments opposing climate engineering is classified under nine main-frames with their sub-frames.

.3.1 Arguments for Climate Engineering

Firstly, we shall present the arguments supporting climate engineering. "Support" here is to be understood in an interpretative sense. If an aspect of the debate seems to imply a justification of the climate engineering project, directly or indirectly, it is being qualified *for*climate engineering. Here we refer to climate engineering in general and do not distinguish between the different categories of it, nor do we distinguish between researching into climate engineering and the actual deployment of climate engineering. The following are the leading ethical contenders *for*climate engineering.

Table 7: Main Frame Arguments

[6]The provisional nature of the classification of the *for* and *against* arguments, and of the number of papers listed for the argument frames and the organisation of the sub-frames is not ruled out. Possible multiple-perspectivities of arguments that are interpretative are ignored in their classification. A paper is qualified for listing if only a particular argument is developed and advanced by it, engaging it at some length. The listing of the paper under the *for* and *against* positions does not imply a definitive position of the author *for* or *against*. Our concern precisely is with individual arguments, and not with the overall position of the paper or the individual views of the authors. Accordingly, the same paper may find mention both under the *for* and the *against* division, relative to the argument, as the case of the argument may be. Betz and Casean (2012), in their study too had encountered the same complexity of the argument reconstructions. According to them, "…argument reconstructions are always interpretations. This being definitely true for coarse-grained analysis, it is also fact that, when compiling a detailed argument reconstruction, there is always room for interpretation that one can fill in one way or another. Hence, there is no such thing as the one and only correct reconstruction of a controversy." Gregor Betz and Sebastian Casean, *Ethical Aspects of Climate Engineering* (Karlsruhe: KIT Scientific Publishing, 2012), p. 13. Downloadable at http://digibib.ubka.dni-karlsruhe.de/volltexte/1000028245, 2012. Downloaded on December 5, 2013.

	Argument Frames	Number of Papers
1	Climate Emergency Arguments	51
2	Feasibility Arguments	32
3	Arguments in Favour of Climate Engineering Research	25
4	Lesser Evil Arguments	17
5	Public Good Arguments	6
6	Ecological Arguments	4

Table 8: Main Frame Arguments with Sub-frames

(In the literature, a number of ethical perspectives and principles may be identified as supporting a particular main frame argument. In this table, a set of such arguments supporting a main frame argument is organised as the sub-frames to the main frames.)

	Arguments Framing	***Number of Papers***
1	**Climate Emergency Arguments (51 Papers)**	
	The 350 ppm target of CO_2 concentration in atmosphere	11
	No Alternative Methods	10
	Preparation for Climate Emergency	8
	Buys more time for mitigation	4
	Negligible Side effects	4
	Global Temperature be maintained below 2^0C	3
	Climate Sensitivity to be kept below 4k	3
	The Sick Patient Metaphor	3
	Species extinction to be averted	2
	Climate engineering facilitates mitigation	2
	Contextual Justification of the most vulnerable (Desperate Argument)	1
2	**Feasibility Arguments (32 Papers)**	
	Cost-effective/Cost-benefit	18
	Do-it-alone	5
	Life-style Argument	5
	Creates Job	1
	Short-Term Deployment	1

	Equity	2
3	**Argument in Favour of Climate Engineering Research (24 Papers)**	
	Bottom-up approach (Public Engagement)	14
	Feasible Informed consent	3
	Responsibility to future generations	3
	False Exclusiveness	2
	Research as Innovation	1
	Knowledge enhancement argument	1
4.	**Lesser evil Argument (17 Papers)**	
	Variations of the Precautionary Principle	8
	Survival Challenge	4
	Arm the Future Argument	3
	Maximin Rule	2
5	**Global Public Good (6 Papers)**	
	Application of Oxford Principles[7]	5
	Concern for Public good	1
6	**Ecological Arguments (5 Papers)**	
	An otherwise anthropogenic climate emergency Argument	2
	Artful Solution	3

3.3.1.1 Climate Emergency Arguments

The whole debate seems to be stemming from a consensus between the proponents and opponents of climate engineering in regard to the dangerous climatic changesthat the earth has already crossed several climate "tipping points" and a dangerous phase transition, or crossing a "climate threshold" is almost inevitable given the low returns from mitigation policies. The variants of the climate emergency arguments are the need for containing the carbon level below 350 ppm, maintaining global temperature below 2^{0}C from preindustrial levels, keeping climate sensitivity below 4K, averting the disintegration of the continental ice-sheets, preparation for climate emergency, desperate argument, absence of other alternatives to counter the failure of mitigation, buy-time argument for mitigation, facilitating mitigation, and averting species-extinction.

[7] For a detailed explanation of the Oxford Principles, please see 6.2.1.4.

As we would see below,[8] there are some borderline environmentalists who hold different opinions on the various climate change assessment. Such dissenting opinions do not seem to be taken seriously by the various parties involved in the climate engineering debate. Also, the desperation with the present mitigation strategies is almost an unquestionable proposition among the proponents and opponents of climate engineering. Naturally, the concern about averting dangerous climate change is the leading argument for climate engineering with 51 papers[9] dealing with this issue. "Climate change catastrophe,"

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[8]See 3.4.2.4.

[9] Bracmort and Lattanzio 2013, p.8; Kjetil Gramstad and Sigve Tjøtta, "Climate Engineering: Cost Benefit and Beyond," *Working Papers in Economics*, Department of Economics, University of Bergen, Norway, 23. September 2010, available at at http://mpra.ub.uni-muenchen.de/27302/ MPRA Paper No. 27302, p. 4, accessed on March 9, 2014; Clive Hamilton, "Ethical Anxieties About Geoengineering: Moral Hazard, Slippery Slope and Playing God," Paper presented to a conference of the Australian Academy of Science Canberra, 27 September 2011,available athttp://www.homepages.ed.ac.uk/shs/Climatechange/Geo-politics/ethical_anxieties_about_geoengineering.pdf, p.2, accessed on March 9, 2014; Jay Michaelson, "Geoengineering: A Climate Change Manhattan Project," *Stanford Environmental Law Journal* 17 (January 1998):1-53, p. 30; David B.Resnik and Daniel A. Vallero, "Geoengineering: An Idea Whose Time Has Come? *Journal of Earth Science and Climate Change* (December 2011), p. 4, available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3596048/, accessed on March 9, 2014; Scholte et al. 2013, pp. 3-5, Betz and Casean 2012, pp.115-8; Sebastian Harnish and Stephanie Uther, "The Global Governance of Climate Engineering – Draft of a Research Agenda," available at http://www.climate-engineering.uni-hd.de/md/climate-engineering/projects/people/harnisch-uther_2010_-_isa_paper.pdf, p. 2, accessed on March 9, 2014; Hannes Fernow, "Complex Risks and the Limits of Cost-Benefit Analysis," in Dorothee Amelung, Wolfgang Dietz, Hannes Fernow, Daniel Heyen, David Reichwein, and Thilo Wiertz, *Beyond calculation - Climate Engineering Risks from a Social Sciences Perspective,*" *Forum Marsilius-Kolleg*, 02 (2012), p. 12, available at http://journals.ub.uni-heidelberg.de/index.php/forum-mk/article/viewFile/9408/Amelung_et_al, accessed on March 9, 2014; Wolfgang Dietz, "Cooperation behind the Veil of Ambiguity," in Dorothee Amelung, Wolfgang Dietz, Hannes Fernow, Daniel Heyen, David Reichwein, and Thilo Wiertz, *Beyond calculation - Climate Engineering risks from a social sciences perspective*, p. 20; Royal Society 2009; Banerjee 2011, p. 19.; Banerjee 2011, p.22; James Hansen et al., *Dangerous Human-Made Interference with Climate: A GISS Model Study,* 7 Atmospheric Chemistry & Physics (2007): 2287-2312, *available at* http://pubs.giss.nasa.gov/docs/2007/2007_Hansen_etal_1.pdf, accessed on December 9, 2013; C. Greene, B. Monger, and M. Huntley, "Geoengineering: The Inescapable Truth of Getting to 350," *Solutions* 1 (2010), pp. 57–66; William C. G. Burns, "Climate Geoengineering: Solar Radiation Management and its Implications for Intergenerational Equity," *Stanford Journal of Law, Science and Policy* (May 2011), p.38, available at http://web.stanford.edu/group/sjlsp/cgi-bin/orange_web/users_images/pdfs/61_Burns%20Final.pdf, accessed on September 4, 2014; William C. G. Burns, "Geoengineering the Climate: An Overview of Solar Radiation Management Options," *Tulsa Law Review* 46:282(2012), available at: http://ssrn.com/abstract=2041131, p.285, accessed on September 4, 2014; Bracmort and Lattanzio 2013, p.7; Burns 2011, p. 51; Clive Hamilton, "The Ethical Foundations of Climate Engineering," 2011a, available at http://www.schrogl.com/03ClimateGeo/DOKUMENTE/205_HAMILTON_ETHICAL_FOUNDATION_CLIMATE_ENGINEERING_2011.pdf, p. 19, accessed on March 27, 2014; Gabriel Hinding, "The Ethics of Solar Radiation Management: Absolutely Necessary or Too Dangerous?," University of Pittsburgh, Swanson School of Engineering Submission (2013):1-4, p. 2; Sean Low et al., "Geoengineering Policy and Governance Issues," *Blackstock Encyclopaedia of Sustainability Science and Technology* (New York: Springer, 2012): 4104-4119; Banerjee 2011; Clive Hamilton, "Ethical Anxieties About Geoengineering: Moral Hazard, Slippery Slope and Playing God, 2011b, Paper presented to a conference of the Australian Academy of Science Canberra, 27 September 2011, *available at http://www.homepages.ed.ac.uk/shs/Climatechange/Geo-politics/ethical-anxieties_about_geoengineering.pdf, . pp. 1-18; accessed on July 3, 201;*David Keith., Parson E., Morgan M., "Research on Global Sunblock Needed Now," *Nature* 463 (2010): 426–427; Banerjee 2011, p.16; Hamilton 2011b, p. 19; Resnik and Vallero 2011, p.3; Banerjee 2011, 20; Hamilton 2011b, p. 19; Seth D. Baum et al., "Double Catastrophe: Intermittent Stratospheric Geoengineering Induced By Societal Collapse," *Environment, Systems and Decisions* 33:1 (2013):168-180, available at https://link.springer.com/article/10.1007/s10669-012-

"dangerous climate change," "climate emergency," etc., are the various jargons coined to represent the situation.

The sequence of scientific positions on the emerging climate change problem may be lined up as follows: Anthropogenic greenhouse gas emission leads to CO_2 concentration above 350 ppm which would shoot the climate sensitivity of the earth above 4 K and the resultant imbalance in the radiation budget of the earth causes the global warming above 2^0C, leading to continental ice sheet melting and rise in sea level. The final corollary of this sequence of events is the mass extinction of the species including human beings. Balancing of the radiation budget of the earth is necessary to keep climate sensitivity below 4 K failing which global warming would exceed 2^0C from the preindustrial phase.

The dangerous climate change anxiety is based on the scientific data that the present CO_2 concentration is about 380 ppm and it is likely to go up. There will be severe consequences if CO_2 levels are not brought down to 350 ppm within decades. 11 papers are alarming the dangers of the high levels of CO_2 concentration.[10] The implicit argument is that the carbon cycle needs to be addressed effectively by technical intervention and technical removal of the carbon invokes the various climate engineering technologies of carbon dioxide removal. The melting of the continental ice sheets, resultant rise in the sea level, and the

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9429-y, accessed on January 21, 2014; Dane Scott, "Geoengineering and Environmental Ethics," *Nature Education Knowledge* 3:10 (2012a):10; Daniel Heyen, "An Economic Perspective on Risks of Climate Change and SRM – Limitations of Methodology, New Concepts and the Precautionary Principle," in Dorothee Amelung, Wolfgang Dietz, Hannes Fernow, Daniel Heyen, David Reichwein, and Thilo Wiertz, pp. 34-40; Keith 2010a; Hamilton 2011b, p. 19; Stephen M. Gardiner, "Is 'Arming the Future' with Geoengineering Really the Lesser Evil? Some Doubts About the Ethics of Intentionally Manipulating the Climate System (February 19, 2009), *Climate Ethics: Essential Readings* (Oxford, 2010b), available at SSRN: https://ssrn.com/abstract=1357162 2013b, p. 28; Stephen M. Gardiner, "The Desperation Argument for Geoengineering," January 2013c, *Symposium*, pp. 28-33, available at https://www.cambridge.org/core/journals/ps-political-science-and-politics/article/desperation-argument-for-geoengineering/23D9326AEA5756D07C05DA7B24140A86, accessed on January 23, 2014; Dorothee Amelung, "Psychological and Social Risk Evaluation Criteria," in Dorothee Amelung, Wolfgang Dietz, Hannes Fernow, Daniel Heyen, David Reichwein, and Thilo Wiertz, *Beyond calculation - Climate Engineering Risks from a Social Sciences Perspective*," 2012b, p.41; Barrett 2008; J. Goodell, "H*ow to Cool the Planet: Geoengineering and the Audacious Quest to Fix Earth's Climate* (New York: Houghton Mifflin, 2010); Royal Society 2009; Crutzen 2006; B. Hale, "You Say 'Solution'" I Say 'Pollution,' 2009, available at http://scienceprogress.org/2009/08/ocean-fertilization-ethics/ 2009, accessed on December 3, 2013; Dale Jamieson, "Ethics and Intentional Climate Change," *Climatic Change*, 33: 323-336 (1996); Michaelson 1998, 10-15; Michaelson 1998, p. 17; Edward A. Parson and David W. Keith, "End the Deadlock on Governance of Geoengineering Research," *Science* 339 (2013); Banerjee 2011, p. 19, Hamilton 2011, p. 2.

[10] Bracmort and Lattanzio, p.8; Gramstad and Tjøtta 2010, p. 4; Hamilton 2011, p.2; Michaelson 1998, p.30; Resnik and Vallero 2011, p.4; Gardiner 2006; Scholte et al. 2013, pp.3,4,5; Betz and Casean 2012, 2012, pp.115-8; Harnisch and Uther 2010, p. 2; Fernow 2012, p. 12; Dietz 2012, p.20.; Royal Society 2009; Banerjee 2011, p. 19.; Banerjee 2011, p.22. Hansen 2006; Green 2010; Burns 2012, p. 285; Burns, 2011, p.38; Bracmort and Lattanzio, p.7; Burns 2011, p. 51. Hamilton 2011b, p. 19; Hinding 2013, p. 2; Low 2013.

destruction of coastal cities warrant the urgency of the climate problem.[11] The climate history shows that slightly higher global temperatures can cause the disintegration of the continental ice sheets.[12]Climate engineering is a “band-aid against abrupt climate change.”[13] The fear of climate sensitivity exceeding 4 K is looming up.[14] A balancing of the “radiation budget of the earth”[15] is necessary to avoid the rise of the global warming above 2^0C from the preindustrial period. The tragic consequences of global warming are a tangible danger.[16] Worst of it all, the extinction of diverse species and even of the human species cannot be ruled out in a dangerous climate scenario.[17] Some estimates have it that by 2050, 15-37% of the species might be extinct.[18]

The absence of effective alternative methods to counter such a drastic climate tragedy is yet another factor justifying climate engineering. The insufficiency of the Kyoto protocol and the climate change as an absent problem can be effectively addressed only with climate engineering.[19]Michaelson (1998) holds that climate change is not a vivid, but an “absent problem.”[20]By absent problem, Michaelson (1998) means that the adverse effects of global climate changeand the real problems associated with such climate change have yet to manifest themselves. Climate change as an absent problem can be addressed by climate engineering.[21] The failure of the mitigation policies to meet their targets is a matter aggravating the call for technically addressing the problem.[22] Paradoxically, as opposed to the moral hazard fears that climate engineering would play down the mitigation agenda, Michaelson and Parson represent the position that climate engineering might even facilitate mitigation by triggering greater awareness in regard to climate change. Parson (2013) presents four scenarios linking climate engineering and mitigation suggesting how climate

[11] Banerjee 2011; Hamilton 2011b, p. 19; Keith et al. 2010.
[12] See Betz and Casean 2012, p.117.
[13] Banerjee 2011, p. 21.
[14] Heyen 2012, pp. 35-40; Keith 2010a; Hamilton 2011b, p. 19; Betz and Casean 2012, pp.117-118.
[15] Betz and Casean 2012, p.118.
[16] Resnik and Vallero 2011, pp.2-3; Banerjee 2011, p.16; Hamilton 2011b, p. 19.
[17] Baum et al. 2013, p.7; Scott 2012a, p. 9.
[18] See Scott 2012a, p. 9.
[19] Amelung 2012b, p.41; Barret 2008; Goodell 2010; Royal Society 2009; Crutzen 2006; Hale 2009; Royal Society 2009; Jamieson 1996; Michaelson 1998, pp. 10-15.
[20] Michaelson 1998, p. 7.
[21] Michaelson 1998, p. 17.
[22] Bracmort and Lattanzio 2013, p.7; Burns 2011, p.38; Resnik and Vallero 2011, p. 4.

engineering might enhance mitigation incentives.[23] Mitigation as a strategy against global warming also implies the "cruel irony"[24] of the prisoner's dilemma.[25]

In the context of the climate emergency, Gardiner identifies a "desperate argument" in the justification of climate engineering. This is the argument that the initiatives of coastal or island nations and peoples who are most vulnerable to the climate changes, out of their desperate attempts at saving themselves, might provide a contextual justification for climate engineering.[26] It provides a sort of self-defence argument for unilateral deployment of climate engineering.

Therefore, from the perspective of the climate emergency, climate engineering should be seen as an intelligent way of being prepared for such a situation in advance. For Bracmort and Laatazio (2013), it is a "Contingency Plan" to be ready "on the shelf."[27] Thus, there is the frequent coinage of metaphors like, 'Plan B' "Insurance Policy," etc., referring to climate engineering. For Gramstad and Tjotta (2010),[28] this should be an "emergency tool" against the "Damocles' sword of massive biotic disruption."[29] In addition, there is the additional merit of "buying-time." Climate engineering would allow more time for mitigation to take effect by holding up the sudden impacts of unabated climate changes.[30]

The proponents of climate engineering do not engage substantively with the allegations on the side-effects of the technology. They have a presumed consequentialist justification in various respects such as, the pros would outweigh the cons,[31] mitigation too has side-effects,[32] no perfect foresight of all consequences is possible,[33] side-effects can be

[23] Parson 2013; Michaelson 1998, p. 17.
[24] Resnik and Vallero 2011, p. 4.
[25] Prisoner's Dilemma is an analogy to the moral problem of achieving individual and collective benefits by cooperating or not cooperating. Individual interest may hinder societal benefit and only collaboration would result in collective benefit. Non-cooperative behaviour may make one better off temporarily, but in the end, everybody ends up worse off. See, S. Gardiner, "A Perfect Moral Storm: Climate Change, Intergenerational Ethics, and the Problem of Moral Corruption," *Environmental Values* 15 (2006): 397–413; Resnik and Vallero 2011, p. 4.
[26] Gardiner 2013b, pp. 28-29.
[27] Bracmort and Lattanzio 2013, p. 8.
[28] Gramstad and Tjøtta 2010, p. 4.
[29] Michaelson 1998, p. 30.
[30] Banerjee 2011, p. 19; Royal Society 2009, p. 47; Hamilton 2011, p. 2.
[31] Hinding 2013, p. 2.
[32] Resnik and Vallero 2011, pp. 3-5.
[33] Goodell 2010, p. 135.

minimized through research,[34] etc. Therefore, the side effects of climate engineering are negligible.[35]

The literature also draws the sick-patient analogy in defence of developing climate engineering.[36] The ethical argument of the lesser evil is implicit in this argument. The argument uses the analogy of a sick patient. The metaphor of the sick patient is applied to the earth, whereby by 2050, the earth is supposed to be akin to a terminally sick patient. In the case of a terminally sick, in medical practice, the exercise of risky and high dose medicines evading the normal standards is warranted. So too, in case of a climate emergency, regular and normal ethical standards will have to be kept aside and extra-ordinary measures may have to be adapted to save the fate of the earth. Climate engineering would be morally justified in such a climate emergency.

3.3.1.2 The Lesser Evil Argument

Many authors consider the lesser evil argument as "the major argument in favour of research into climate engineering."[37]A random look at the spectrum of debate would somewhat endorse this point. The forced-choice context of a climate catastrophe, the arm-the-future argument, the variations of the precautionary principle, the maximin rule, the survival argument and the sick-patient argument are the varying subsets of the lesser evil argument mostly debated in the context of a moral justification for climate engineering.

There are 15 papers dealing with the lesser-evil issue.[38] Accordingly, this may be treated as one of the leading arguments for climate engineering. The argument from lesser evil was

[34] Betz and Casean 2012, p. 33.
[35] Betz and Casean 2012, p. 18.
[36] Betz and Casean 2012, pp. 34-35.
[37] Gregor Betz, "The Case for Climate Engineering Research: An Analysis of the 'Arm the Future' Argument,'" *Climatic Change* 111 (2012), p. 473.
[38] These 15 papers are selected on the basis of the reference to the concept of lesser evil in the moral sense. The reference to lesser evil in these papers could be in favour of geoengineering or against it, or to some extent supporting both positions. In this section, we are only assessing those lesser-evil arguments that seem to endorse the geoengineering causes. The papers dealing with lesser-evil arguments are: Betz and Casean 2012;Betz 2012; Adam Corner and Nick Pidgeon, "Geoengineering the Climate: The Social and Ethical Implications," *Environment* 52 (2010): 24-37; Gareth Davies, "Framing the Social, Political, and Environmental Risks and Benefits of Geoengineering: Balancing the Hard-to-imagine against the Hard-to-measure," *Tulsa Law Review* 46 (2011): 101-122; Stephen M. Gardiner, "Is 'Arming the Future' with Geoengineering Really the Lesser Evil? Some Doubts about the Ethics of Intentionally Manipulating the Climate System," in Stephen M. Gardiner et al, eds. *Climate Ethics* (Oxford, New York: Oxford University Press, 2010a):284-313;Stephen M. Gardiner, "Some Early Ethics of Geoengineering the Climate: A Commentary on the Values of the Royal Society Report," *Environmental Values* 20 (2011): 163–188; Gardiner 2013b, pp. 28-33; Clive Hamilton, "The Ethical Foundations of Geoengineering," in Wil C. G. Burns and Andrew L. Strauss, eds., *Climate Change Geoengineering: Philosophical Perspectives, Legal Issues, and Governance Frameworks* (New York: Cambridge University Press, 2013): 39-58; Christopher J. Preston, "Re-Thinking the Unthinkable: Environmental Ethics and the Presumptive Argument Against Geoengineering," *Environmental Values* 20

part of the debate from its early conceptions. Jamieson and Schneider (1996) who have in a way pioneered the ethical debate on the issue had recourse to this point. "(R)esearch should continue on whether ICC (intentional climate change) can be carried out in a way that is consistent with the conditions that I have outlined. My reason for this is straightforward: we may reach a point at which ICC is the lesser of two evils."[39] "I do (somewhat reluctantly) agree that study of geoengineering potential is probably needed […], given our growing inadvertent impact on the planet and the possibility that other alternatives are worse."[40] Crutzen's (2006) prediction of a "worst case scenario" implicitly carries the same idea.[41] This argument finds further credibility in the present day climatic apprehensions that how hard we may try, the target 2^0C may not be reached.

The lesser evil argument has the presumed assumption that mitigation and adaptation are the preferred options for tackling climate problems; and climate engineering has inherent ethical problems and is to be considered as an evil though of a lesser degree and this would be justified in the context of a do or die situation. Gardiner observes that "appeals to the lesser evil are attractive to a wide audience, including those who are otherwise strongly against technological intervention."[42] Gardiner (2010b) calls it "the arm the future argument," in short, the AFA.[43] The arm the future argument holds that if the present plans with mitigation are not successful, in future, the humanity will be forced to make a choice between doing climate engineering or allowing the catastrophic disaster to take place. Given these choices, humanity will certainly have to make the choice for doing climate engineering. Therefore, it is important at present to prepare for that future choice by engaging in climate engineering research. It is a way of enabling or arming the future generations to make a choice for climate engineering to save the earth and hence it is called the arm the future argument.[44] The arm the future argument is a variation of the lesser evil argument with greater focus on the future scenario. Arm the future argument also focuses on the concrete

(2011): 457–479; Christopher J. Preston, "Ethics and Geoengineering: Reviewing the Moral Issues Raised by Solar Radiation Management and Carbon Dioxide Removal," *WIREs Climate Change* 4 (2013): 23–37. Shane J. Ralston, "Geoengineering as a Matter of Environmental Instrumentalism," available at SRN: https://ssrn.com/abstract=1630480, accessed on December 29, 2013; David B. Resnik and Daniel A. Vallero, "Geoengineering: An Idea Whose Time Has Come?," *Journal of Earth Science and Climate Change*, December 17; Suppl 1 (2011): 1-18; Samantha Scholte, Eleftheria Vasileiadou & Arthur C. Petersen, "Opening up the Societal Debate on Climate Engineering: How Newspaper Frames are Changing," *Journal of Integrative Environmental Sciences* 10:1 (2013): 1-16; Scott 2012a; Toby Svoboda, "The Ethics of Geoengineering: Moral Considerability and the Convergence Hypothesis," *Journal of Applied Philosophy* 29(2012a): *243-256.*

[39] Jamieson 1996, pp. 332f.

[40] Schneider 1996, pp. 300f.

[41] Crutzen 2006

[42] Gardiner 2009, p. 3.

[43] Gardiner 2009.

[44] Gardiner 2009, p. 3.

justification of the research and development into climate engineering. The AF argument thus implies consequential "conditional predictions," for a future scenario and "normative assumptions" and "general normative principles" for evaluating specific options in that scenario.[45]

The AF argument is further supported by the precautionary principle and the maximin rule. Precaution may be understood in general as the caution that is exercised in an uncertain context. When there are scientifically ambiguous consequences in terms of harm and benefits, precautionary principle prefers adapting the ethical stand of first avoiding harm. One of the basic forms of the precautionary principle in the context of environment was advocated by the article 15 of the Rio Declaration on Environment and Development. It stated: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[46] Several authors take recourse to the many variants of the precautionary principle in the context of the climate engineering.[47]Reichwein opines that"precautionary Principle is currently the most promising approach to SRM, although clarification on the specific applicability and the legal impacts of the principle is necessary."[48] Similarly, Daniel Heyen (2012) in his economic analysis of the risk for climate engineering advocates the usage of precautionary principle.[49] Ralston assumes that the precautionary principle as well as the Rio Declaration[50] warrant overlooking the uncertainties "where there are threats of irreversible harm to the environment and by implication the quality of life for future generations."[51] A moderate coinage of the precautionary principle in the context of the large-scale uncertainties involved in climate engineering is invoked by

[45] The phrases are of Betz 2012, p. 476.
[46] David Reichwein, "Basic Instruments to Tackle Risks and Uncertainties in International Environmental Law," in Dorothee Amelung, Wolfgang Dietz, Hannes Fernow, Daniel Heyen, David Reichwein, and Thilo Wiertz, 2012, p. 29.
[47]Reichwein 2012;Heyen 2012; Betz and Casean 2012; Davies 2011, pp. 101-122; Benjamin Hale & Lisa Dilling. "Geoengineering, Ocean Fertilization, and the Problem of Permissible Pollution," *Science, Technology, & Human Values* 36 (2011): 190-212; *Chris Jones et al,* LWEC Geoengineering Report: A forward Look for UK Research on Climate Impacts of Geoengineering (2013):1-41; Chunglin Kwa & Mieke van Hemert, "Engineering the Planet: The Issue of Biodiversity in the Framework of Climate Manipulation and Climate Governance," *Quanderni* 76 (2011): 79-89; Rafael *Leal-Arcas and Andrew Filis-Yelaghotis,* "Geoengineering a Future for Humankind: Some Technical and Ethical Considerations," CCLR 2 (2012):128-148; John Virgoe, "International Governance of a Possible Geoengineering Intervention to Combat Climate Change," *Climatic Change* (2009): 103–119; David A. Wirth, "Engineering the Climate: Geoengineering as a Challenge to international Governance," *Environmental Affairs Law Review* 40 (2013): 413-437.
[48]David Reichwein 2012, p. 25.
[49] Heyen 2012.
[50] See, Gardiner 2009, p. 22.
[51] Ralston 2011, p. 829.

Resnik and Vallero (2011).[52] In this view, "research on geoengineering should continue, but specific proposals should not be implemented unless we have good evidence concerning their safety, efficacy, and feasibility. Small-scale, low-risk climate engineering projects, such as reforestation or the use of physical or chemical processes to remove CO_2, should be attempted prior to implementing large, risky projects, such as SO_2 spraying or fertilizing the oceans."[53] Against the arguments of the detractors of climate engineering who invoke the precautionary principle to dissuade research, Resnik and Vallero (2011) cautions that, "An overly precautionary approach toward something so time-sensitive and potentially irreversible as climate change could result in missed opportunities."[54] The appeal to the ethical norm of maximin principle[55] is spontaneously drawn in the context of precautionary principle in relation to lesser evil. The maximin principle or maximin criterion is a principle advocated by John Rawls in his *Theory of Justice* (1971). Gregor Betz (2012) formulates the maximin principle as follows: "Of a set of alternative choices, the one with the highest minimal possible payoff is rationally to be preferred."[56] Like the precautionary principle, this is also a principle for making a decision under uncertainty. It holds that an action should be favoured where the worst loss from that action will be better than the minimum loss from all other actions possible in the given context. The enthusiasts for research and development in climate engineering suggest that the application of maximin rule would endorse their cause.

The forecast of a possible climate emergency in the future and the normative assumption that the worst consequences of not doing climate engineering will be worse than the worst consequence of doing climate engineering seem to support the case of lesser evil argument. What are the possible worst consequences of not doing climate engineering? The scenario envisaged is formulated in extreme categories by most authors. "Nightmare scenario," "climate emergency," "climate catastrophe" are some of the terms coined in the literature in this regard.[57]

Some of the literature highlights the worst scenario of the extinction of the human species itself. Survival of the human species might itself be dependent on our ability to geoengineer now.[58] This is termed as survival argument by Gardiner (2010).[59] Applying the

[52] Resnik and Vallero 2011, p. 9.
[53] Resnik and Vallero 2011, p. 9.
[54] Resnik and Vallero 2011, p. 11.
[55] The Maximin principle or Maximin criterion is a principle advocated by American philosopher John Rawls in his *Theory of Justice*.
[56] Betz 2012, p. 476.
[57] See, for example, Gardiner 2009, pp. 15-16.
[58] Baum et al. 2013.

concern for survival to a wider context, climate engineering is considered by some authors as a conservation of the global ecosystem and it may be treated as the only remaining possibility.[60]

3.3.1.3 **Arguments in Favour Climate Engineering Research**

Another major line of the debate identifiable in the literature, which is closely related to the climate emergency arguments, pertains to the research and development of climate engineering. As climate engineering is a seminal science, still to take off the launch pad, the preliminary question is, is research and development of climate engineering desirable at all? Knowledge enhancement argument, innovation argument, responsibility to future generation, easiness to obtain informed consent, and false exclusiveness,[61] are the major subsets of the arguments pertaining to research ethics in climate engineering. As an alternative or complement to mitigation, research and development into climate engineering makes it ready for deployment in case of an emergency. The innovation argument holds that research can "trigger spin-offs and create jobs."[62] Research does enhance our knowledge of the science of climate engineering.[63] The possibility of obtaining informed consent through representative bodies makes the feasibility of research relatively easy despite the complex nature of the informed consent in such a global concern.[64]

Another compelling motivation for research and development is our responsibility to future generations whereby our present planning and design matter quite a lot for the well

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[59] Its formulation goes: "If very substantial progress on emissions reduction is not made soon, then the world may plunge into chaos because of catastrophic climate change. If this happens, my family may face a choice between starvation and fighting for its own survival. Both starvation and fighting for survival are bad options. But fighting for survival is less bad. Therefore, if we are forced to choose, we should choose fighting for survival. But if we do not begin serious preparations for fighting for survival now, then we will not be in a position to choose that option should the circumstance arise. Therefore, my family needs to commence serious preparations for fighting for survival now." Gardiner 2009, p. 22.

[60] Keith, in Goodell 2010, p. 39; Baum et al. 2013, p. 3

[61] The phrases knowledge-enhancement, innovation argument, and false exclusiveness in the geoengineering setting are of Betz and Casean 2012.

[62] Betz and Casean 2012, p. 28; Barrett 2008.

[63] R. Cicerone, "Geoengineering: Encouraging Research and Overseeing Implementation," *Climatic Change*, 77 (2006): 221-226.

[64] Corner and Pidgeon 2010, p.29; David R. Morrow, Robert E Kopp, and Michael Oppenheimer," Toward Ethical Norms and Institutions for Climate Engineering Research," Environmental Research Letters 4 (2009): 1-11. Aavailable at http://www.iop.org/EJ/article/1748-9326/4/4/045106/erl9_4_045106.html[12/8/2009. Accessed December 23, 2013; Anthony Lieserowitz "Climate Change and Geoengineering in the Public Mind," Presentation at Asilomar International Conference on Climate Intervention Technologies (slide 12). Available at http://www.climateresponsefund. org/images/Conference/leiserowitz-4-24-10-red.pdf. Accessed March 30, 2014.

being of future generations in a fast changing climate scenario.[65] Fernow (2012) thinks that "research into SRM techniques can alternatively be considered as our moral duty, since arming the future might present us with an opportunity to pay off our CO_2-'debt'."[66] Refusal to research now would "lead to a shifting of the 'problem', i.e. some of the risks, to some future generation."[67]

Ruling out the misconception that mitigation and climate engineering exclude each other would provide another justification for research and development. According to Keith (2000), mitigation and climate engineering do not exclude each other.[68]Forming public opinion and ensuring public engagement from the outset are serious points extensively discussed in the literature. There are at least 15 papers dealing with public engagement in climate engineering and that too on an optimistic note exploring various models of engaging the public.[69] Upstream public engagement,[70] supermajority rule,[71] and Participatory Democratic Governance of bottom up model,[72] are some of the models proposed in the literature towards forming and appraising the public view on research into climate engineering.

3.3.1.4 Feasibility Arguments

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65 Corner and Pidgeon 2010, p. 29; Morrow et al. 2009; Lieserowitz in Preston 2013, p.29; Amelung 2012b, p.46; Fernow 2012, p. 12; Banerjee 2011, p.24.

66 Fernow 2012, p. 13.

67 Thilo Wiertz, "From Prediction to Critique: The Moral Hazard Debate," in in Dorothee Amelung, Wolfgang Dietz, Hannes Fernow, Daniel Heyen, David Reichwein, and Thilo Wiertz, *Beyond calculation - Climate Engineering Risks from a Social Sciences Perspective,*" 2012, p. 49.

68 Keith 2000a.

69 Amelung 2012b, pp.41-48; Blackstock et al. 2009, p. 4; Corner and Pidgeon 2010; ETC 2009; Corner and Pidgeon 2010, p.32ff; Gramstad and Tjøtta 2010, p.13; Hulme 2009, pp.698-9; P. Macnaghten, and B. Szerszynski, "Living the Global Social Experiment: An Analysis of Public Discourse on Geoengineering and its Implications for Governance," *Global Environmental Change* 23 (2013): 465–74; Shobita Parthasarathy, Lindsay Rayburn, Mike Anderson, Jessie Mannisto, Molly Maguire, Dalal Najib, *Geoengineering in the Arctic: Defining the Governance Dilemma, Science, Technology and Public Policy Programme*, Gerald R. Ford School of Public Policy, University of Michigan, 17.6.2010. STPP Working Paper 10-3, available at http://stpp.fordschool.umich.edu/policy-consultations/GAO%20papers/Item%20B17-Geoengineering%20in%20the%20Arctic,%20GAO%20STPP%20Working%20Paper%2010-3.pdf, accessed on February 9, 2014; Prantl 2011, p.4; Preston 2013, p. 28; P. Macnaghten and R. Owen, "Good Governance for Geoengineering," *Nature* 479 (November 2011), p. 293; Marc Poumadèrel, Raquel Bertoldo, Jaleh Samadi, "Public Perceptions and Governance of Controversial Technologies to Tackle Climate Change: Nuclear Power, Carbon Capture and Storage, Wind, and Geoengineering," *Climate Change* 2 (2011): 712–727.

70 Corner and Pidgeon 2010.

71 Gramstad and Tjøtta 2010, p.13.

72 Parthasarathy et al. 2010.

The feasibility arguments constitute a bulk of the defensive positions on climate engineering. The general assumption in the feasibility arguments is that climate engineering compared to mitigation has several practical advantages in that it is cheap and cost-effective, easily deployed, avoids unnecessary compromise with the present life-style, etc. Since a nation can single-handedly or a small group of nations jointly can develop and deploy climate engineering, it does not invite the hurdles of collective decision-making and international consensus. Betz and Casean (2012) call it the do-it-alone argument.[73] Further, a small group of nations will be able to execute the project.[74] Many other authors also have treated this easiness as assuring the success of climate engineering.[75]Michaelson (1998) also sees that it minimises the institutional roles making it administratively simpler.[76]

Cost-effectiveness and efficiency are the most projected elements highlighted under the feasibility position with a number of at least 18 papers developing this part of the debate.[77] Bracmort thinks that compared to mitigation, future technology might still bring down costs.[78] The scientific analysis of Emmerling (2013) has shown that SRM is very likely to be effective.[79] Gramstad (2010) claims that climate engineering passes the cost-benefit test.[80] Hinding is very articulate that the pros of climate engineering outweigh the cons.[81]Michaelson (1998) goes one step further to argue that mitigation is more expensive than climate engineering[82] and it has the secondary economic benefit of being an eco-friendly technology and it is cheaper in political economic terms.[83] Preston (2013) considers climate engineering to be effective as SRM will be fast, cheap, efficient, and naturally observed in the

[73] Betz and Casean 2012, p. 38.

[74] K. Ott, 2010a. Argumente für nd wider, "Climate Engineering," *Versuch einer Kartierung. Technikfolgenabschätzung - Theo- rie und Praxis*, 19, 2: 32-43; K. Ott, 2010b. Die letzte Versuchung - Eine ethische Betrachtung von Geo-Engineering. *Politische Ökologie* 120: 40-43; K. Ott, 2010d. Kritische Kartierung der Argumente der Klimam- anipulation. In Jahrbuch Ökologie 2011. Stuttgart: S. Hirzel. These articles originally published in German are commented in English by Betz and Casean (See, pp. 151-152). Hence their inclusion in this review.

[75] Banerjee 2011, p.16; Ott 2010a, b, d.; Betz and Casean 2012, p.118; Baum et al. 2013, p.9; Gardiner 2013b, p.29ff; Michaelson 1998, p.17.

[76] Michaelson 1998, p. 20.

[77] Fernow 2012, p.12ff, 34ff; Banerjee 2011, p.19; K. C. Elliot, "Geoengineering and the Precautionary Principle," *International Journal of Applied Philosophy*, 24 (2010): 237-253; Greene et al. 2010; A. Robock, "Whither Geoengineering," 320 (May 2008c): 1166-7; Ott 2010a,b,d in Betz and Casean 2012, p.118; Gardiner 2010, p. 287; Elliot 2010; Wood in Goodell 2010, p. 129; Bracmort and Lattanzio 2013, p.7; Davies 2011, p.116, 121; Johannes Emmerling et al. "Geoengineering and Abatement: A 'flat' relationship under Uncertainty," *Nota Di Lavoro* 2013, available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2251733, accessed on March 1, 2014; Gramstad and Tjøtta 2010, pp.11-12; Hinding 2013, p. 2. Michaelson 1998, p. 8, 17.; Michaelson 1998, p. 18; Mooney et al. 2012, p. 220; Preston 2103, pp.23-24; Scholte et al. 2013, p. 9..

[78] Bracmort and Lattanzio 2013, p.7.

[79] Emmerling 2013.

[80] Gramstad and Tjøtta 2010, pp. 11-12.

[81] Hinding 2013, p. 2.

[82] Michaelson 1998, pp. 8, 17.

[83] Michaelson 1998, p. 18.

Pinatubo effect.[84] Svoboda (2012) shows SAG (Sulphate Aerosol Geoengineering) has less net harm than mitigation and other forms of climate engineering.[85] Lane and Bickel's research claimed that "the benefit- to-cost ratio of research and development of SRM technologies is 'on the order of 1000 to 1."[86] Leal-Arcas (2012) too considers it to be least expensive and quick.[87]

The life-style argument could also be placed alongside the advantages of climate engineering. While mitigation poses serious challenges to the style of living, habits and economics ways of the present civilization, climate engineering avoids the challenges of having to address the root causes of the climate problems.[88] Accordingly it is also described as the "easiness argument"[89] for climate engineering. There is the single claim by Wigley (2000) that short-term deployment of certain variants of climate engineering is possible, adding to the effectiveness of climate engineering.[90]Although there are only somenominal arguments in defence of climate engineering from the perspective of justice, the two observations related to equity could be treated broadly under the effectiveness of the climate engineering. Michaelson (1998) observes that climate engineering, broadly treated, is fairer than mitigation provided we agree that the ideal world never exists.[91] He also claims that climate engineering avoids the tragedy of commons.[92]

3.3.1.5 **Public Good Arguments**

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[84] See Chapter 2; 2.3.5. Preston 2103, pp. 23-24.

[85] Toby Svoboda, "Is Aerosol Geoengineering Ethically Preferable to Other Climate Change Strategies?" *Ethics & the Environment*, 17 (2012b): 111-135.

[86]James Eric Bickel and Lee Lane, "'Climate Change: Climate Engineering Research and Development," Copenhagen Consensus Center, May 2012; available at http://www.copenhagenconsensus.com/sites/default/files/climatechangeengineeringr26d.pdf: 1-32, p.3. Accessed April 28, 2014. See also, Mooney et al. 2012, p .220.

[87] Leal-Arcas and Filis-Yelaghotis 2012, p. 12.

[88] Banerjee 2011, p.19; Ott 2010 a,b,d in Betz and Casean 2012, p. 118; Davies 2011, p.121; Hale 2012, p.21; Michaelson 1998, p.30.

[89] Betz and Casean 2012, p.38.

[90] Wigley in Goodell 2000, p. 133.

[91] Michaelson 1998, p. 19.

[92] "A tragedy of the commons occurs when each user of a common resource, in using that resource, reduces the value of the resource to herself to a degree smaller than the amount of utility she receives from the use, and reduces the value of that resource to all users to a degree greater than the amount of utility she receives from the use…. The case of climate change presents an imperfect tragedy of the commons, because international actors face varying degrees of expected harm and benefit from their use of the common resource." Michaelson 1998, p. 21.

Given the large scale and long-term impact of climate engineering some authors suggest treating climate engineering as a global public good.[93] The consideration of climate engineering as a public good was developed in the Oxford principles for climate engineering. The Oxford principles for climate engineering were developed and submitted to UK House of Commons in 2009. Oxford Principles recommended that climate engineering should be treated and regulated as a public good. Reyner et al (2011) consider the climate engineering projects, including research and deployment, within the framework of the Oxford principles.[94] Preston comments that "Oxford principles are notable for stipulating that climate engineering should not be driven by profit-raising questions…"[95] The Royal Society (2009) has also underscored the role of the public participation along similar lines.

3.3.1.6 **Ecological Arguments**

A final category of arguments promoting the cause of climate engineering may be termed as ecological arguments. They are branded as ecological arguments because they presuppose a vision of nature and human's relationship to nature. The ecological arguments have a revised understanding of the earth-system, opposed to the radical environmentalists, which permits desirable intervention with nature. Not surprisingly, only five papers[96] have been identified to be dealing at some length with these arguments. Preston (2011) counters the "ecofascism" of the deep environmentalists.[97] Refusal to do climate engineering can be tantamount to ecofascism because in case of an emergency it would mean letting the humans to die to keep the earth system unperturbed and that might lead to the extinction of the human species.[98] He envisages a hypothetical situation where climate engineering would be more a responsible obligation to the earth system. It is an imaginary situation if climate engineering was warranted by sudden climate changes caused by other than anthropogenic factors. He wonders if climate engineering would have been desirable in such a circumstance.[99] In this

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93 S. Rayner, "Climate Change and Geoengineering Governance," 2011; available at http://www3.ntu.edu.sg/rsis/nts/HTML-Newsletter/Insight/NTS-Insight-jun-1102.html, pp.1-9. Aaccessed on November 4, 2014; Preston 2013, p. 27.

94 S. Rayner, C. Redgwell, J. Savulescu, N. Pidgeon, T. Kruger, Oxford Memorandum Submitted to the House of Commons Select Committee on Science and Technology, 2009b. Available at: http://www.geoengineering.ox. ac.uk/oxford-principles/history/. Accessed December 29, 2013.

95 Preston 2013, p. 28.

96 Preston 2011; Preston 2013; A. Robock, M. Bunzl, B. Kravitz, and G.L. Stenchikov, "A Test for Geoengineering?" *Science* 327 (2010): 530- 531; Shane J. Ralston, "Engineering an Artful and Ethical Solution to the Problem of Global Warming,"*Review of Policy Research* 26: 6 (2009): 821-837; Ralston 2011.

97 Preston 2011, p. 471.

98 Preston, p. 471.

99 Preston asks: "If it were the case that humans had not released large quantities of greenhouse gases into the atmosphere and that the world was warming naturally at the same dangerous rate that it is now warming due to

case, Preston (2011) raises the philosophical issues concerning the fundamental relationship between humans and the earth. The earth's large-scale biogeochemical processes should not be understood in isolation from the human well being. He says, "The values embodied in earth's basic biogeochemical systems are not so high that they trump human interests…"[100]

Based on John Dewey's concept of artful inquiry, Ralston (2009) considers climate engineering as an artful solution to climate emergency.[101] According to Ralston (2009), "Research on climate engineering ought to continue, as should research on mitigation and adaptation. In varying degrees, all of these are artful and ethical ways to preserve the atmosphere for future generations, and, at the same time, ways for us to behave as responsible members of the greater geocommunity."[102]Climate engineering also has the potential for increased plant productivity and more colourful sunsets,[103] which also are tantamount to the ecological benefits.

3.3.2 Arguments against Climate Engineering

The opponents of climate engineering field an array of arguments which not only counters the arguments for climate engineering, but also opens up new battlefields from several frontiers spanning through climate science, philosophy, social sciences, and political concerns, to geo-ecological consequences and risk ethics.

The arguments against climate engineering shall be shortly outlined here along the scheme presented in Table 9.

Table 9: Main Frame Arguments:

	Arguments Frame	**Number of Papers**
1	Scientific Objections	68
2	Feasibility Objections	61
3	Issues of Risk	56

anthropogenic greenhouse gases, would the environmentalist presumption against geoengineering be enough to preclude taking measures to prevent the impending change?" Preston 2011, p. 471.

[100]Preston 2011, p. 472.

[101] Shane J. Ralston, "Engineering an Artful and Ethical Solution to the Problem of Global Warming,"*Review of Policy Research* 26: 6 (2009): 821-837, p.834; Ralston 2011, p. 21.

[102] Ralston 2009, p. 834.

[103] A. Robock, M. Bunzl, B. Kravitz, and G.L. Stenchikov, "A Test for Geoengineering?" *Science* 327 (2010): 530- 531.

4	Governance Concerns	45
5	Concerns with Technical Fix	41
6	Arguments from Justice	37
7	Deep Ecology Arguments	35
8	Moral Hazard	32
9	Arguments Opposing Climate Engineering Research	30

Table 10: Main Frame Arguments with Sub-frames

(The various arguments and principles that are found to be complementing a main frame argument are organised as a sub-frame under the main frame. This table presents the list of the main frame and sub-frame arguments ranked in the order of the number of papers.)

1.	**Scientific Arguments Sub-frames (68 Papers)**	
	Unseen Side-effects	24
	Irreducible Uncertainties	20
	Earth System Complexity	8
	There are Scientific Alternatives for Averting Climate Changes	6
	Only Partial Offset by Climate engineering	6
	Climate engineering might Worsen Catastrophic Changes	3
	Worst Scenario compared to the failure with mitigation	1
2.	**Feasibility Sub-frames (61 Papers)**	
	Large scale field tests are problematic	27
	Sudden Termination Problem	17
	False claims of Cost-effectiveness	7
	Questionable Effectiveness	3
	Factor of Possible Human Error	3
	Non-reliable Forecast	2
	Irreversible Intervention	2
3	**Risk Ethics Sub-frames (56 Papers)**	
	Unestimated risks	20
	Unilateral Deployment	14
	Commercialisation of Technology	12
	Militarisation of Technology and Possible climate Wars	9
	Dual Use of Technology	1

4	**Governance Issues Sub-frames (45 Papers)**	
	Complexity of Governance	34
	Inadequacy of Existing International Laws	7
	Uncertain International Cooperation	2
	Impossible Long-term control	2
5	**Concerns with Technical Fix (41 Papers)**	
	Technical Fix	15
	Treating Symptom over cause	8
	Techno-escalation (Slippery slope)	7
	Hubris Argument	5
	Futuristic Argument	3
	Intentional Intervention (Principle of double effect)	3
6	**Justice Concerns Sub-frames (37 Papers)**	
	Intergenerational equity	17
	Unequal Distribution of Cost and Benefits	9
	Compensation Issues	4
	The Predator evasion paradox	3
	Survival of the Fittest	1
	Difference Principle	1
	Egalitarianism	1
	Human Rights	1
7	**Deep-ecology Arguments Sub-frames (35 Papers)**	
	Rights of Non-human species	7
	Playing God	6
	Domination of Nature	5
	Aesthetic concerns	4
	Unwarranted deviation in the anthroposcene	4
	Respect Argument	3
	Anthropological Argument	3
	Holistic Argument	2
	Non-interference Argument (Non-anthropocentric Argument)	1
8	**Moral Hazard (33 Papers)**	
9	**Arguments Opposing Climate Engineering ResearchSub-frames (30 Papers)**	
	Concern with Moratorium on Research and Field Tests	12

	Research leads to Deployment	9
	Problems with Informed Consent	5
	Passing the Buck to future generations	3
	Future Dilemma Scenario	1

3.3.2.1 Scientific Objections

The various arguments closely linked to the findings of the climatic sciences are clustered together as the scientific arguments. In our scheme of classification of arguments, the scientific arguments have the most number of hits with 68 references. Unseen side-effects of climate engineering, irreducible uncertainties, earth-system complexity, possibility of alternative means, partial offset of anthropogenic climate change, etc., are the sub-sets of the scientific arguments against climate engineering.

3.3.2.1.1 Side-effects of Climate Engineering

With very little research and field tests having been done and with no precedence of the technological exercise to such a global magnitude, geoengineering scientists, theorists, and ethicists are highly apprehensive about the potential side-effects of geoengineering. Almost every paper expresses a genuine concern over the consequences and 24 of our selected sources develop the debate in terms of the side-effects of geoengineering.[104] Climate scientists have identified a series of side-effects for the various constituencies of geoengineering. The fear of the projected side-effects prevents the technology from taking off. The major side-effects of geoengineering related to climate and environment extensively discussed in the literature are the following: prolonged ocean acidification, aggravating ozone depletion, sunlight reduction resulting in reduced solar power production, implementation impacts like noise, pollution, debris, etc., increased whitening of the skies, challenges to the terrestrial optical astronomy and satellite remote sensing, reduction in global precipitation, irregular monsoons, increased acid deposition, extinction of the Amazon forests, greater

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[104] Harnisch and Uther 2010, p. 4; Dietz 2012, pp. 20-21; Banerjee 2011, p. 17; Banerjee 2011, p.16; Banerjee 2011, p. 31; P.G. Brewer, "Evaluating a Technological Fix for Climate," *Proceedings of the National Academy of* Sciences104 (2007): 9915-9916; Bunzl 2011; ETC 2009; Hale 2009; G. C. Hegerl and S. Solomon, "Risks of Climate Engineering," *Science* 325 (2009): 955-956; Keith 2000a; C. L. Parkinson 2010; A. Robock, "20 Reasons Why Geoengineering May Be a Bad Idea," *Bulletin of the Atomic Scientists* 64 (2008b):14-18, pp.15-16; Virgoe 2009; Jamieson 1996, p. 326; ETC 2009, p.34; Baum et al. 2013, p. 7; Baum et al., 2013, p.8; Burns 2012, p. 289ff; Corner and Pidgeon 2010, p.31-32; Hinding 2013, p. 2; Jones et al. 2013, pp. 30-31; Keith 1998, pp. 10, 12; Preston 2013, p. 31ff.; Resnik and Vallero 2011, p. 7; Resnik and Vallero 2011, p.8; Virgoe 2009, pp. 107-108.

formation of tropospheric cirrus clouds,[105] food and water scarcity in regions of Saharan Africa and Asia due to interference with the with Asian and African monsoon patterns,[106] possible drought in Southeast Asia, slowest flow of Ganges and Amazon, potential health hazards from increased ozone depletion like increased skin cancer, and cataract leading to one million death, adverse challenges to marine ecosystem, reduction in agricultural production, biogeochemical cycles and forest productivity,[107] potential threats to the ecosystems and livelihoods in polar regions due to high concentrations of "wash-out" sulphate particles,[108] reduction in the net primary productivity of North America by 50-100%,[109] challenges with the space-based systems like the sunshades sailing out of the orbit, tracking problems, imposing logistical problems like unprecedented scale of production of mirrors and long time-span required for production, impossibility of replacing trillions of flyers, failure of rockets and their possible collisions, as well as the formation of orbital debris clouds.[110]More specifically, ocean fertilization may result in "Changes in marine primary production, biodiversity and food webs; increased ocean interior anoxia and acidification; also increased N_2O and CH_4 release."[111] Direct carbon capture may also damage the deep-sea ecosystems and increased acidification of ocean.[112] Ocean fertilization can also cause oxygen depletion leading to methane release and changed mix of ocean biota.[113] Preston's (2013) description of the incidental impacts also shares the same anxieties.[114] The speculative nature of the predictions, trans-boundary impacts of the technology, and, unequal distribution of the side-effects further worsen the case.[115] A study on deploying sulphate aerosols held for the US Department of Defence showed that it "could explicitly constitute hostile weather modification."[116]

3.3.2.1.2 Irreducible Uncertainties[117]

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[105] Robock 2008b, pp.15-16.
[106] Banerjee 2011, p. 17.
[107] Burns 2012, pp. 289ff.
[108] Burns 2012, p. 292.
[109] Burns 2012, p.294.
[110] Burns 2012, p. 296.
[111] Jones et al. 2013, p. 30.
[112] Jones et al. 2013, p. 31.
[113] Keith 1998, p. 10.
[114] Preston 2013, p. 31.
[115] Dietz 2012, p. 20; Keith 2000a, p. 276; Robock 2008a; ETC 2009, p. 34.
[116] Banerjee 2011, p. 31.
[117] It could be noted that the subsets of argument frames such as side-effects, uncertainties and risks are very much interwoven and sometimes overlapping. However, we treat them distinctively avoiding repetition for a better analysis of the moral issues at stake in them. While our treatment of the side-effects and uncertainties would be focusing exclusively on the scientific and technical concerns, risk ethics will have broader purview of concerns embracing the social, moral, and political issues too. Side effects, here, is coined mostly in the environmental sense as referring to the direct and contextualized impact on weather and climate. Risks refer

An introductory reading of the literature on the ethics of climate engineering gives the impression that the whole debate is operating against the backdrop of huge uncertainties. Uncertainty becomes an imposing limit on almost every aspect of the entire debate. From 21 papers, this review identifies a few of the leading technical uncertainties that are ethically relevant.[118] In regard to SRM and the CDR method of the air capture of CO_2, there are many uncertainties prevalent in regard to their benefits and harms. As for the afforestation technique, there is uncertainty about "calculating baselines and the permanence of carbon sequestration."[119] For ocean based techniques, there is uncertainty about the fate of carbon in ocean and the P:N utilization ratio[120] of eco-systems. The rate of carbon accumulation under changing climates is a challenge to carbon capture techniques. Costs, life-time, feasibility, and aerosol transport and its effect on cloud optical properties are uncertain matters for SRM.[121] Resnik and Vallero (2011) find that uncertainties are very high with regard to the radiant gases, their cooling forcing as well as albedo. In climatic engineering techniques, a small change in initial conditions can lead to results totally different from the expected. A minor mistake can therefore cause unintended and unknown results.[122] Tanaka calls for

mainly to the potential indirect impacts on the social and political domains. Risks are remote and extended side-effects transcending contextual boundaries. Whereas by uncertainty, here, we refer to the inadequacy of the scientific data, research gaps and the still speculative aspects in the proposed technologies as opposed to the essential features of scientific knowledge like exactitude, certainty, objectivity, and mathematical accuracy. It is acknowledged that in climate engineering proposals, uncertainty pertains to side effects and risks as well.

118 Baum et al., 2013, p.8.; Banerjee 2011, pp.24-25; Harnisch and Uther 2010; Fernow 2012; Dietz 2012, p.23; L. Bengtsson, "Geo-Engineering to Confine Climate Change: Is it at all Feasible?" *Climatic Change* 77 (2006): 229-234; Hegerl and Solomon 2009; C. L. Parkinson 2010; Royal Society 2009; Wood, R. et. al 2013; Schneider 2008; Corner and Pidgeon 2010, p.31; Keith 2000a, p.277; Robock 2008a; Bunzl 2009; Keith 2000, p. 270-271; Keith 1998, pp. 10, 12; Moreno Cruz, Rex Victor, Hideo Harasawa, and Murari Lal, 2007, 'Asia', in Martin L. Parry, Osvaldo F. Canziani, and Jean P. Palutikof(eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge: Cambridge University Press, pp. 469–506, available at http://www.ipcc.ch/pdf/assessmentreport/ar4/wg2/ar4wg2chapter10.pdf, accessed on July 3, 2014; Resnik and Vallero 2011, p.8, 9; Resnik and Vallero 2011, p. 9; K. Tanaka et al., "Geoengineering to Avoid Overshoot: An Uncertainty Analysis," Abstract, *Geophysical Research Abstracts*, Vol. 11, EGU2009-14133, 2009, EGU General Assembly 2009, available at http://adsabs.harvard.edu/abs/2010EGUGA.1212796T, accessed on September 30, 2014; Philip Williamsona et al., "Ocean Fertilization for Geoengineering: A Review of Effectiveness, Environmental Impacts and Emerging Governance," *Process Safety and Environmental Protection* 90 (2012): 475–488.

119 Banerjee 2011, pp. 24-25.

120 In the ocean, there is a close relationship between the oceanic cycles of life's essential elements—carbon, nitrogen (N) and Phosphorus (P)—with the metabolic requirements of phytoplankton. Nitrate and phosphate have one of the strongest correlations in the sea. This correlation is similar to the average nitrogen (N) to phosphorus (P) content of plankton biomass. However, the processes through which this global relationship emerges are not known. (See, Thomas S. Weber and Curtis Deutsch, "Ocean Nutrient Ratios Governed by Plankton Biogeography," *Nature* 467 (30 September, 2010): 550-554.

121 Keith 2000a, pp. 270-271.

122 Resnik and Vallero 2011, pp. 8- 9.

uncertainty analysis to avoid overshoot.[123]Williamson (2012),[124] relying on various studies conducted by others, warns about the uncertainties in regard to the measure of mid-and deep-water production of nitrous oxide (N_2O) and methane (CH_4), from the decomposition of additional sinking biomass. It is suggested that Nitrous oxide and Methane are 320 times and 20 times greater potential than CO_2 in causing global warming. Therefore, any increase in their production and their reach in the atmosphere would have serious consequences that would offset the desired results of CO_2 Sequestration.[125]

3.3.2.1.3 Earth-system Complexity

This argument holds that the earth system may be more complex than what science has presently understood and any tampering with it or intentional manipulation of it would result in dangerous climatic changes. The assumption here is that any technical attempt to cool the earth would affect the earth as a whole. As the Royal Society has summarized, one of the perspectives on the potential role of geoengineering is that "it represents a dangerous manipulation of Earth systems and may be intrinsically unethical."[126] Fernow (2012) holds that "… it is crucial for the comprehensive regulation of complex and sensitive processes to bear in mind thatpossible adverse, irreversible consequences of planetary-scale manipulations could emerge exactly from the unforeseeable and non-linear dynamics of ecological and social systems."[127] The complexity of the earth-system does not allow understanding or controlling the climate system in a reasonable manner.[128] Preston (2011) identifies a *prima facie* reason, a presumptive argument emerging in the opposition against climate engineering. "The presumptive argument is bolstered by recognition of the extraordinary complexity of earth's ecological system and often a deep scepticism about scientists' ability to manage it."[129] Gardiner's (2010a) coining of the "unthinkable action"[130] carries the very thought of

[123] Overshoot, according to Tanaka, "is a feature accompanied by low stabilizations scenarios aiming for a stringent target … in which total radiative forcing temporarily exceeds the target before reaching there." The plans to achieve a 50% emission reduction by 2050 is likely to produce overshoot. See, Tanaka et al. 2009.
[124] Williamsona et al. 2012, p. 481.
[125] J. A Fuhrman, D.G. Capone, "Possible Biogeochemical Consequences of Ocean Fertilization," *Oceanogr* 36 (1991): 1951–1959; C. S. Law, "Predicting and Monitoring the Effects of Large-scale Ocean Iron Fertilization on Marine Trace Gas Emissions," *Marine Ecology Progress Series* 364 (2008):283–288; available at http://dx.doi.org/10.3354/meps07549. Accessed on August 2014; X. Jin and N. Gruber, Offsetting the Radiative Benefit of Ocean Iron Fertilization by Enhancing N2O Emissions," *Geophysical Research Letters* 30 (2003): 2249–2252, http://dx.doi.org/10.1029/2003GL018458. Accessed on June 5, 2014.
[126] Royal Society 2009, p. 45.
[127] Fernow 2012, p. 16.
[128] ETC 2009, p. 34, Bjornar Egede-Nissen, "Scientists in the Geoengineering Discourse: Social Advocates or Neutral Umpires?" Paper prepared for the workshop "The Ethics of Geoengineering: Investigating the Moral Challenges of Solar Radiation Management" at the University of Montana, 18–20 October 2010. Available at http://www.politicalscience.uwo.ca/research/docs/articles/graduate/student_documents/bjornar.pdf, pp. 1-21, p. 4, accessed on June 23, 2015.
[129] Preston 2011, p. 464.

climate engineering as morally undesirable and something very counter-intuitive. The perspective of the earth as a self-regulating system for habitation also needs to be correlated with this idea.[131]

3.3.2.1.4 Worsens Dangerous Climate Change

As opposed to climate engineering as an insurance policy, it is argued by the opponents that climate engineering might worsen the dangerous climate change.[132] Baum et al. (2013), for example, envisages a double catastrophe scenario where a natural calamity halts the sulphate aerosol injection leading to sudden rise in temperature, which results in the extinction of the human species itself.[133] In the long run, the worst case without geoengineering might be better than the worst case with mitigation.[134]

3.3.2.1.5 Potential Scientific Alternatives

Apart from mitigation and adaptation, the opponents argue, that the scientific community must rigorously look into alternative ways of countering the anthropogenic climate changes. Biochar, air capture methods, zero emission vehicles or alternative energy sources, adequate mass education, population control, etc., might provide viable alternatives to climate engineering.[135] If these alternative approaches are seriously implemented, climate change would be less alarming and there would be no need for a technological fix. Besides, the alternative approaches will not in any way play down the mitigation efforts as they share the same concerns driving the mitigation strategies.

3.3.2.1.6 Only Partial Offset[136]

Climate engineering can address only a small portion of the diverse consequences of anthropogenic climate changes. It is not anything effective in addressing such changes comprehensively with a complete control over the thermostat.[137] There are several vital areas that are not addressed by it. For instance, the albedo enhancement does not remove the

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130 Gardiner 2010, p. 299.
131 Lovelock, in Goodell 2010.
132 Betz and Casean 2012, p. 121; Baum et al., 2013.
133 Baum et al. 2013.
134 Betz and Casean, p. 134.
135 Wiertz 2012, p.54; Banerjee 2011, p. 16; Greene et al. 2010; B.Hale 2009; Michaelson 1998, p. 9, 15.
136 Phrase is of Betz and Casean 2012.
137 Gardiner 2010, p. 288; Robock 2008a,b; ETC 2009; p.17; Martin Bunzl, "Geoengineering and the Problem of Comparative Judgements of Harm," *American Geophysical Union* (2007). Available at http://adsabs.harvard.edu/abs/2007AGUFMGC52A.12B. Accessed on February 23, 2015.

concentration of the CO_2 in the atmosphere, but only allows it to continue, and ocean acidification and its challenges to marine life would still remain untouched. Therefore, geoengineering solutions, though it may be successful in some respects, cannot be considered to be an integral response to climate change. It is not worth investing in a strategy that will not bring in a sustainable solution.

3.3.2.2 Arguments Opposing Climate Engineering Research

There are many arguments opposing research and development of climate engineering. The ethical debate here is also informed by epistemic, cultural and democratic factors. Issues related to informed consent, intergenerational ethics including the rights of future generations, the precautionary principle, and research value, are the leading sub-sets of arguments in this section. 30 papers are raising these issues in a manner worth mentioning.

9 out of these 30 papers are directly confronting the very idea of research. Arguments in them consider research to be intrinsically unjustifiable.[138] A major concern about any research in this context is that research inevitably leads to deployment.[139] "If the development of climate engineering technologies will automatically lead to their deployment, the situation we end up in by doing research and development is not a situation where we have two alternative options. The decision to engage in research now predetermines the deployment. Research and development does therefore not increase the number of options we have in the long run."[140] According to Jamieson (1996), "there is a serious risk that ICC projects will be implemented even if they are unwarranted…. in many cases research leads unreflectively to development."[141] As Jamieson (1996) has noted, here there is a cultural imperative not to oppose progress. For many opponents, research is no goal in itself.[142]

Preston (2013) fears that climate engineering researches are prone to the problems of "path-dependency" or "lock-in."[143] Technological lock-in would mean that the "the pressure to implement climate engineering from vested institutions could potentially overwhelm the caution the technology demands."[144] It invites the slippery slope of formation of interest groups involved in research and those groups acting as pressure groups. Resnik and Vallero's

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[138] Jamieson 1996; Bengtsson 2006; Gardiner 2010, 288ff; Jamieson 1996, 333ff; Betz 2012, p.476; Bracmort and Lattanzio 2013, p. 8. Preston 2013, p. 28; Resnik and Vallero 2011, p. 5; Tuana 2012.
[139] Gardiner 2010, pp.289; Betz 2012, p.476.
[140] Betz 2012, p. 477.
[141] Jamieson 1996, p. 333.
[142] Gardiner 2010, 288ff; Jamieson 1996:333ff.
[143] Preston 2013, p.28.
[144] Preston 2013, p. 28.

(2011) concern with an epistemic problem of science becoming tainted with private funding opposes the cause of research.[145]

There is yet another stream of argument along the line which may be termed as the "anachronistic" argument. According to this argument, the present understanding of climate engineering technology may not be compatible with the nature of climate engineering technology 50 years from now. As technological advancements are occurring at unprecedented levels, future generations may be able to develop better technologies for averting climate changes. The present generation cannot anticipate a state-of-the-art technology of the future now. Therefore developing a technology, using the present technical know-how, which may take several decades to be ready for deployment is undesirable.[146]

Then there is the issue of intergenerational ethics. The very planning of research implies that the future generations are already made parties to the problem and we transfer the risks of CE to them. Betz and Casean (2012)call it the "risk-transfer argument."[147] Instead of addressing the problem of mitigation here and now, the present generation comfortably "passes the buck" to future generations.[148] The risk-transfer scenario throws the future generations into a situation in which their choices and rights are conditioned in an ethically unacceptable manner.[149]

Promoting research into climate engineering at this juncture will have serious other ramifications. Bracmort and Lattanzio (2013) observe that "Government endorsement prematurely stamps geoengineering activities as acceptable; and given the nascent state of understanding in the science, a rush toward implementation may result in potentially dangerous proposals being mistakenly promoted and potentially useful techniques mistakenly ignored."[150] Besides, in a society where various research projects are striving for funding, a huge sum spent on climate engineering research will be a setback to several other researches which may be of immediate benefit to the society. Prioritization of climate engineering will displace other knowledge enhancing projects.[151] Besides, there is the likelihood of climate engineering research turning out to be trivial.[152]

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[145] Resnik and Vallero 2011, p. 5.
[146] Schelling 1996; Gardiner 2010, p. 289, Betz 2012, p. 477.
[147] Betz and Casean 2012, p. 56; Ott 2010a,b,d; Gardiner 2010, p. 293; Jamieson 1996, p. 331.
[148] Gardiner 2010, p. 295.
[149] Ott 2010c.
[150] Bracmort and Lattanzio 2013, p. 8.
[151] Gardiner 2009, p.7.
[152] Gardiner 2009, p. 7.

Obtaining informed consent for climate engineering research is very problematic. The principle of informed consent holds that a person who will be subjected to a research or a party who will be affected by the research should be told about the implications and risks of the research and his/her consent must be obtained for carrying out the research. In the case of climate engineering, the conventional understanding of informed consent faces many limitations. It is difficult to clearly identify the parties who will be affected by climate engineering. Even if they are identified, that will be a huge number of masses of populations for such a globally impactful technology. It is difficult to get a unanimous consent from a huge population. In that case, it may be argued that the representative consent of populations may be sufficient. However, the representative consent also involves several concerns like who is to represent and what is the norm for forming the opinion to be represented. The desperate or self-defence scenarios as highlighted by Gardiner also invoke the issue of informed consent. Assuming informed consent in a desperate scenario does not absorb the complexity of the problem.[153]

There are 8 papers dealing with a moratorium on climate engineering tests.[154] Different variants of the precautionary principles are invoked by different authors even for a ban or moratorium on climate engineering.[155] The weak version of the precautionary principle states that the precaution of avoiding harm should be given preference in case of a choice under uncertainty. There are several elements of uncertainty and potentials risks in climate engineering. This is adequate reason for a ban on climate engineering as a precaution against the adverse impacts on the ecosystem. Besides, the worries about moral hazard, the possible commercial misuse of technology are arguments listed for a ban or moratorium.

3.3.2.3 Feasibility Objections

The opponents of climate engineering squarely confront the claims of the proponents that it is a feasible and efficient technique compared to mitigation and adaptation. The feasibility objections are classified under the sub-units of large-scale field tests, termination problem, irreversible interventions, possible human errors, cost-effective deficiencies, etc. In aggregate, there are 61 papers developing the debate from the perspective of feasibility. The

[153] ETC 2009; Hale 2009; Hale 2011; Morrow et al. 2009, p. 4; Gardiner 2013b, pp.28-29.
[154] Cicerone 2006; ETC 2099; Leal-Arcas and Filis-Yelaghotis 2012, pp. 137-139; Schneider 2008; Goodell 2010, p. 2000; Bracmort and Lattanzio 2013, p.23; Mooney et al. 2012, p. 224; Resnik and Vallero 2011, p. 9.
[155] Bracmort and Lattanzio 2013, p. 7; Mooney et al. 2012, p.224; Banerjee 2011, p. 27; Elliot 2010.

large-scale impact of climate engineering poses serious ethical issues. The feasibility and permissibility of such a large-scale technique is questionable for non-encapsulated system.[156]

As of 2013 there were about 8 field tests at a small-scale which were either executed or planned and these tests do not seem to have produced anything significant towards climate engineering research, apart from spanning controversies.[157] The climate engineering studies are still relying on computer simulations, which are far from actual tests, and there are serious inconsistencies with these simulations.[158] There are several papers questioning the reliability of small-scale tests, the very possibility of tests, the propriety of "trial and error" method at such a larger scale, the application of do-no-harm principle and minimization principle.[159]

The problem of sudden termination or the exit problem is lavishly raised in the literature questioning the feasibility of climate engineering. There are 17 papers dealing with this problem.[160] The shared anxiety is that a sudden termination of the aerosol injection or any such methods would result in a sudden rise in temperature, which would aggravate the dangerous climate change scenario. The long-term deployment makes it an irreversible intervention and non-stoppable development.[161] The feasibility is further challenged by the possibility of human error.[162] The reliability of the forecasts is still questionable.[163] Although climate engineering is presented by the proponents as very cost-effective, there are several arguments challenging the cost-benefit and cost-effective claims. It is shown that most

[156] Bunzl 2009, pp. 2-3; Resnik and Vallero 2011, p. 9.
[157] Amelung 2012b, p. 41 - LOHAFEX expedition in 2009; Amelung 2012b, p.41 - Spicefield experiment in UK; Banerjee, p.16 - Russia's Field Test; Bracmort and Lattanzio 2013, p. 3 - American private test by Martin Lukas; Hamilton 2011, p.11- Patent to Bill Gates; Hulme 2009, p. 697 - field experimentation (e.g. Izrael et al., 2009; Macnaghten and Owen 2011; Hulme 2009, p. 701 - Izrael et al. (2009) conducted limited-area field experiments; Macnaghten and Owen 2011- UK, SPICE Field Trial.
[158] Baum et al. 2013, p. 7, Hulme 2009, pp.700-701.
[159] Banerjee 2011, p. 17; Blackstock et al. 2009; Bunzl 2009; Cicerone 2006; Keith 2010; Morrow et al. 2009; Robock et al. 2010; Betz 2012, p.480; Wood, R. et. al 2013; Elliot 2010: p.11; Leal-Arcas and Filis-Yelaghotis 2012, p. 132; Ronal List,"Do no harm Geoengineering of Climate and Hurricanes," available at https://www.wmo.int/pages/prog/arep/wwrp/new/documents/ENV.List_Roland_Canada.pdf, accessed on Mary 9, 2015; Mooney et al. 2012, p.227; Morrow et al. 2009, p. 7, Tuana 2012, p. 149.
[160] T. M. Lenton and N. E. Vaughan, "*The Radiative Forcing Potential of Different Climate Geoengineering Options*," *Atmospheric Chemistry & Physics* 5539 (2009); Banerjee 2011, p.16; Goodell 2010, p. 21; Baum et al., 2013, p.7; Michael C. MacCracken, "Geoengineering: Worthy of Cautious Evaluation?," *Climatic Change* 77 (2006): 235–243; Robock 2008b, p.17; Robock et al. 2010; Wood, R. et. al 2013; Virgoe 2009; Bracmort and Lattanzio 2013 p.2; Hinding 2013, p.2; Jones et al. 2013, LWEC Report; Leal-Arcas and Filis-Yelaghotis 2012, pp.132-3; Preston 2013, p. 32; Tuana 2012.
[161] Jamieson 1996, p. 333ff; Resnik and Vallero 2011, p. 8.
[162] Robock 2008a, p. 17; ETC 2009, p. 34; Resnik and Vallero 2011, p. 8.
[163] Bengtsson 2006; Jamieson 1996.

analyses fall short of being reliable, ignore the indirect costs, irrelevant due to uncertainty, or even fails in cost benefit test.[164]

3.3.2.4 Governance Concerns

Absence of an adequate governance mechanism poses a serious challenge to climate engineering. It constitutes a hot and heavy debate in the literature with 45 papers developing on this area.[165] The questions of moral authority, instability of political institutions and political strategies, deliberate democratic engagement, political obliviousness, respect for sovereignty are amongst the concerns in governance of climate engineering, which render it an ethically challenging undertaking.International cooperation might turn out to be a big hurdle along the way to governance.[166] The impracticality of long-term control[167] and the inadequacy of the present international laws and treaties further complicate governance.[168]

3.3.2.5 Arguments from Justice

Just as the case with any debate in environmental ethics, justice constitutes one of the central pillars of the climate engineering controversy. The concerns with justice in climate engineering are discussed in detail in the following chapters of this study. Thedue attention paid tojustice in the debate is testified by the intense activity in this field as 37 papers

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[164] Banerjee 2011, p.27; Gardiner 2010, p. 288; Bracmort and Lattanzio 2013, p.7; Royal Society 2009, p.49; Corner and Pidgeon 2010, p. 28; Resnik and Vallero 2011, p.8; Robock 2008, p.17; K. Keller, N. Urban, N. Tuana, "Does Aerosol Geoengineering the Earth's Climate Pass a Cost-Benefit Test?," *American Geophysical Union*, Fall Meeting 2007. Available at http://adsabs.harvard.edu/abs/2007AGUFMGC33A0938K. Accessed November 9, 2016.

[165] Barret 2008; Bodansky 2006; ETC 2009; Keith 2010; Rayner 2011; Robock 2008c; Royal Society, 2009; Virgoe 2009; Betz and Casean 2012; Harnisch and Uther 2010, pp. 2, 5; Wiertz 2012, p. 53; Gardiner 2011, p.184; Arunabha Ghosh, "International Cooperation and the Governance of Geoengineering," Keynote Lecture to the Expert Meeting on Geoengineering, Intergovernmental Panel on Climate Change, Lima, Peru, 21 June 2011. Available at http://ceew.in/pdf/AG_International_Cooperation_IPCC_21Jun11.pdf, pp.1-22, accessed on February 7, 2014; Hale 2012, p.21; Hamilton 2011, pp.6-8; Harnisch and Uther 2010, pp.26-27; Hulme 2009, 699-700; IPCC, p. 38; Leal-Arcas and Filis-Yelaghotis 2012, pp.134-136; Parson 2012; Parthasarathy et al. 2010; Robock 2008b, p.17; Scholte et al. 2013, p.10.; Smith 2010, p.3; Tuana 2012; Virgoe 2009, p. 112ff; Kyle Powys Whyte, "Now This! Indigenous Sovereignty, Political Obliviousness and Governance Models for SRM Research," *Ethics, Policy and Environment*, 15 (2012): 172-187, pp. 175ff; Whyte 2012, p. 178; Whyte 2012, p.178, Wirth; Albert C. Lin, "Geoengineering Governance," *Issues in Legal Scholarship* 8 (2009): 1-26, available at http://escholarship.org/uc/item/481423jp#page-1, accessed August 7, 2016; J. C. Long and D. Winickoff, "The Governance of Solar Radiation Management Research," *American Geophysical Union*, Fall Meeting 2011, Abstract available at http://adsabs.harvard.edu/abs/2011AGUFM.U44B..04L, accessed on December 9, 2016; J. C. Long 2011; Low 2013; Macnaghten and Owen 2011; Macnaghten and Szerszynski 2013; Poumaderel et al. 2011; Williamsona et al. 2012

[166] Ghosh 2011, pp.7-9; Resnik and Vallero 2011, p. 8.

[167] Corner and Pidgeon 2010, p.31; Virgoe 2009, p.108.

[168] Amelung, 2012 b, p.46; Banerjee 2011, p.30; Virgoe 2009; Bodansky 1996; Mooney et al. 2012, p.228; Parson 2012, p. 19ff; Robock 2008b, p. 17.

represent this issue. Intergenerational equity,[169] risk-transfer to future generations,[170] beneficence and Belmont principle,[171] participation of the vulnerable sections,[172] distributive and procedural justice[173] and indigenous people and their involvement,[174] are the major issues pertaining to justice in the context of climate engineering.

The unequal distribution of cost and benefits and benefits and harms is vociferously raised by the advocates of climatic justice.[175] The difference principle, egalitarianism and human rights questions are also introduced in the debate in the context of justice.[176]Rawlsdeveloped the principle of difference in his *Justice as Fairness*.[177] Difference principle is a principle of justice to regulate the distribution of wealth and income amidst social and economic inequalities. It requires that social institutions be arranged in such a way that inequalities in wealth and income must be oriented to the benefit of those who would be worst off. The economic inequalities should be to everyone's advantage, and chiefly to the greatest advantage of the least advantaged. As we would discuss eventually, in the context of climate engineering, the contrary is likely to be the case. The egalitarian fear is that climate engineering might widen the socio-economic inequalities already prevalent in the world. Conversely, it would weaken the just realisation of the human rights. There is also a stream of argument under the justice concerns that those who caused the problem of climate change

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169 Bodansky 1996; S. Gardiner, Is Geoengineering the "Lesser Evil"? (2007). Available at http://environmentalresearchweb.org/cws/article/opinion/27600. Accessed August 8, 2014; Jamieson 1996, p.330ff; Burns 2011, p.41ff Gardiner 2013b, p.30f.

170 Marlos Goes, Klaus Keller and Nancy Tuana, "The Economics and Ethics of Aerosol Geoengineering Strategies," *Geophysical Research Abstracts* 12 (2010), EGU2010-3659, 2010, Available at http://adsabs.harvard.edu/abs/2010EGUGA..12.3659G; Bert Gordijn, Henk ten Have, "Ethics of Mitigation, Adaptation and Geoengineering," *Medicine Health Care and Philosophy* 15 (2012):1–2; Leal-Arcas and Filis-Yelaghotis 2012, p. 130.

171 Morrow et al. 2009, pp.5-9.

172 Preston 2013, p. 28f; Banerjee, p. 22.

173 Preston 2013, p.29ff; Aaron Ray, "Alternative Responses to Climate Change: An Inquiry into Geoengineering," *Sanford Journal of Public Policy* 1 (2010): 35-50, p.3; Toby Svoboda, Klaus Keller, Marlos Goes and Nancy Tuana, "Sulfate Aerosol Geoengineering: The Question of Justice," *Public Affairs Quarterly* 25 (2011): 157-179. Preliminary version available at http://digitalcommons.fairfield.edu/cgi/viewcontent.cgi?article=1025&context=philosophy-facultypubs, pp. 1-41. Accessed August 8, 2015.

174 Whyte 2012.

175 Morrow et al. 2009; Bodansky,1996; Keith 2000a, p.276; Robock 2008a; ETC 2009, p.34; Mooney et al. 2012, p.228; Tuana 2012; Bunzl 2007; Martin Bunzl, comment on "Geoengineering and Equity," Bunzl's Blog, comment posted May 12, 2008, http://ccspp.blogspot.com/2008/05/geoengineering-and-equity.html, comment posted May 12, 2008. Accessed on December 28, 2013.

176 Betz and Casean 2012, p. 44. T. W. M. Pogge, *World Poverty and Human Rights: Cosmopolitan Responsibilities and Reforms* (Malden, MA: Polity Press, 2002). Available at: http://www.loc.gov/catdir/toc/fy036/2002001076.html. Accessed on March 8, 2015.

177John Rawls, J*ustice as Fairness: A Restatement*, E. Kelly, Ed. (Cambridge, MA: Harvard University Press, 2001).

should also solve it.[178]Betz and Casean (2012)call it the polluter-pays principle.[179] Abdicating our responsibility is a kind of injustice to the future generations. Benajmin Hale (2012) calls it the Responsibility abdication objection. In this argument, climate engineering acquits us of our responsibility for our actions. We can get away with our offences without being held responsible for.[180]Climate engineering provides a "get-out-of-jail-free card."[181] The issue of paying compensation to the deprived and the losers is a major problem to be addressed.[182]

3.3.2.6 Moral Hazard Argument

A prominent argument against climate engineering is the moral hazard argument. The notion of moral hazard originates from the insurance context referring to the natural tendency of the insured to be more care-free and experimental than the non-insured. Applied to climate engineering, it is feared that climate engineering possibility will weaken the case of alternative strategies like mitigation and adaptation. The literature on the ethics of climate engineering has an elaborate discussion on the moral hazards associated with climate engineering. We have 32 papers advancing the moral hazard debate.[183]The significant moral hazard arguments opposing climate engineering are mainly the variants of moral hazard like technical dependence hazard, governance hazard, snowball hazard,[184] and Gardiner's deeper ethical hazard. The image of climate engineering as a possible insurance policy against climate change[185] and the likelihood of consolidating present life-style and practices are also considered moral hazards caused by climate engineering. Climate engineering research would invoke the problem of moral corruption.[186] Moral corruption, according to Gardiner is "the subversion of our moral discourse to our own ends."[187] It is because the present generation may underestimate their responsibilities and find rational ways to justify their

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[178]Jamieson 1996, p. 331.

[179] Betz and Casean 2012, p. 59.

[180] Hale Benajamine, "The World that Would Have Been," in Christopher Preston, Ed., *Engineering the Climate:The Ethics of Solar Radiation Management* (Maryland: The Rowman and Littlefield, 2012), pp. 113-132.

[181] J. Shepherd. Cited in Royal Society 2009, p. 37.

[182] Amelung 2012b, p.46; Barrett 2008; Gardiner 2007.

[183] Bracmort and Lattanzio 2013, p. 7; Royal Society 2009, p. 47; Low 2013; Amelung et.al., 2012a, p. 11; Amelung 2012b, p. 41ff; Wiertz 2012, pp.49ff; Banerjee, p.17; Bunzl 2009; ETC 2009, p.34; Gardiner 2007; Gardiner 2010, p. 292; Goodell 2010; Keith 2000a, p.276; E. Kintisch, *Hack the Planet: Science's Best Hope – or Worst Nightmare – for Averting Climate Catastrophe* (Hoboken, New Jersey: John Wiley & Sons, 2010); Robock 2008a, p. 17; Robock 2008b; Virgoe 2009; Jamieson 1996, pp.333ff; Corner and Pidgeon 2010, p. 32; Resnik and Vallero 2011, p. 11 9; Gardiner 2010, p.304; Betz 2012, p. 479; Burns 2011, p.53; Corner and Pidgeon 2010, p.30; Gardiner 2011, p. 184; Hale 2012; Leal-Arcas and Filis-Yelaghotis 2012, p. 132; Lin 2012; Mooney et al. 2012, p.227; Preston 2013, p. 25; Scholte et al. 2013, p.4; Preston 2013, p. 25.

[184] Hale 2012, p.17.

[185] Royal Society 2009, Low 2013.

[186] Gardiner 2010, pp. 286, 291; Hamilton 2011, p.4; Preston 2011, p. 473; Preston 2013, p. 25.

[187] Gardiner 2010, pp. 286, 291.

overconsumption, especially given the hypothetical possibilities opened up by the research. This argument is a variation of the moral hazard argument.

3.3.2.7 Considerations Concerning Risk

As an emerging set of technology with trans-boundary outreach, climate engineering is loaded with many risks that should be taken into account for ethical responses and policy formulations. Apart from the scientific and technical issues like unseen side-effects and uncertainties[188] which are already discussed, climate engineering further invites many potential risks which are to be engaged from the social, political, legal and environmental perspectives. The literature has an exhaustive overview of these risks from multi-perspectives.[189] The danger of unilateral deployment, commercial interests of private stakeholders, potential move towards climate wars, and the danger of dual use are the major non-technical risks.

There are apprehensions about the feasibility of climate engineering to be developed by one or a small group of nations. There can be unprecedented consequences for the deployment of the technology in a non-encapsulated earth system even if it is by a single nation. The results show that the fear of unilateral deployment is a leading contender for the risk ethics with 13 references.[190] The large-scale and long-term impact of climate engineering with its trans-temporal and trans-spatial outreach, coupled with the military motives of some of the stakeholders, makes it an extremely risky practice with the tangible potential for unmitigated conflict of interests which might end up in geopolitical and climate wars.[191] The potential danger of the dual use of technology for military empowerment with the production of weapons of mass destruction is also to be taken into account.[192]

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[188]For the demarcation between side effects, uncertainties and risks that we have made in this chapter, please see footnote no. 117.

[189] Bracmort and Lattanzio 2013, pp. 4-6; Amelung et.al 2012a, p. 9; Fernow 2012, p. 12; Reichwein 2012, pp. 25ff; Barret 2008; Bunzl 2011; ETC 2009; Hegerl and S. Solomon 2009, p.28; Robock 2008; Royal Society 2009; Wood, R. et. al 2013; Keith 2000a, p. 275; Corner and Pidgeon 2010, p. 30; Goodell 2010, pp. 210-12; Robock 2008a; ETC 2009, p.34; Davies 2011, pp. 106ff; Keith 2000a, pp.270-71; Keith 1998, pp. 10, 12; Mooney et al. 2012, p.227; Ray 2010; Tuana 2012.

[190] Banerjee, p.16; Virgoe 2009; Blackstock et al. 2009; Barrett 2008; Bodansky,1996; Goodell 2010, pp.195-7; Bracmort and Lattanzio 2013, p. i; Mooney et al. 2012, p.228; Resnik and Vallero 2011, p.8; Scholte et al. 2013, p.4.; Svoboda et al. 2011; Virgoe 2009, p. 115; Weitzman; Parson 2013.

[191] M. Hulme, Why We Disagree About Climate Change (Cambridge: Cambridge University Press, 2009); D. Keith 2000a; Robock 2008; Wood, R. et. al 2013; Banerjee p.20; Hulme 2009, p. 351; Robock 2008a, p. 17; Corner and Pidgeon 2010, p.30, Macnaghten and Szerszynski 2013.

[192] Keith 2000a, p. 275; Corner and Pidgeon 2010, p. 30; Goodell 2010, p. 210-2; Robock 2008a; ETC 2009, p.34.

The possible commercialisation of technology may invite additional risks for climate engineering technologies. The formation of interest groups with the involvement of private stakeholders with profit motives might divert the technology to commercial ends. Commercialisation of the technology may compromise the genuine motivations of technology and profit motives may expose the technology to the risks of unwarranted or prolonged deployment. It also implies the risk of spoiling the image of science as an objective and trust-worthy practice.[193]

3.3.2.8 Concerns with Technical Fix

The critique of climate engineering in this category is based on foundational conceptual and theoretical assumptions. The problems of technical fix, treating symptom over cause, techno-escalation and hubris arguments[194] are the subsets of arguments for the technological critique. Climate engineering is criticized as a big technical fix of the earth. As such it is an artificial solution envisaging a designer climate. 16 papers are voicing a concern about it.[195] Along the same line, it is argued that climate engineering is fundamentally flawed, as it does not have recourse to the fundamental problematic underneath, rather, prefers to treat the symptom over the cause. It is nothing more than a "band-aid" solution.[196]

The hubris argument is a corollary of the technical fix criticism. The hubris argument refers to the unwarranted faith in the megalomaniac powers of technology which facilitates large scale manipulations in an unbridled manner.[197] In the words of Betz and Casean (2012), it is an "arrogance and a form of self-deceit that will heavily backfire."[198] There is a slippery slope involved in it that it leads to a sort of techno-escalation whereby humanity gets an unacceptable hope in technology preferring designer climate against the natural and the irreversible means over the reversible.[199]

[193] Hamilton 2011, p. 11; ETC 2009, pp. 29, 34; Robock, 2008a, p.17; Robock et al. 2010; Corner and Pidgeon 2010, p.30; Banerjee p. 20; Bracmort and Lattanzio 2013, p.7; Egede-Nissen 2010, p.8; Hale 2012, p.21; Hale 2012, p.18; Leal-Arcas and Filis-Yelaghotis 2012, pp.137-139; Mooney et al. 2012, p.228; Morrow et al. 2009, p.3.

[194] Formulation of Betz and Casean 2012.

[195] Hale 2011; Hale 2009; Keith 2000a; Gardiner 2010, p. 303; ETC 2009, p.5; Corner and Pidgeon 2010, p.30; Hale 2012, p .20; Hamilton 2011a, pp. 17-18.; Hamilton 2011b, p.21; Keith 1998, p.7; Keith 2000a, p. 277; Preston 2013, p. 26; Preston 2013, p. 32; Ray 2010; Scholte et al. 2013, p.10; Scott 2012a, pp. 6-9.

[196] Wiertz 2012, pp.54, 9, 46; Hale,2011; Keith 2000a; Kiehl 2006, pp.227-8; Burns, 2011, p. 53; Hale 2012, p.19; Resnik and Vallero 2011, p.10.

[197] Fleming 2010; Ott 2010a,b,c,d in Betz and Casean, p.124; Gardiner 2009, p. 33; Jamieson 1996, p. 332; Preston 2013, p. 26.

[198] Betz and Casean 2012, p. 48.

[199] Keith 2000a, p. 277; Keith 1998, p.7; Keith 2000a, p. 277; Gramstad and Tjøtta 2010, p.16; Hulme 2009, p.697; Preston 2013, p. 32.

3.3.2.9 Deep-ecological Arguments

Deep-ecology, an offshoot of the ecological thinking since 1980s, is understood here as a philosophical perspective which views the earth, human and the diverse infrahuman species as an integral part of the web of life. It challenges the anthropocentric view of life, admonishes the instrumental approach towards the infrahuman, and attributes an intrinsic value to every species. Relationality is the key element in deep-ecology. The relational matrix of the web of life emphasised by the advocates of deep ecology provide a conceptual framework for categorising some of the critique against artificial solutions in climate engineering. Accordingly, climate engineering is viewed as a totally different phase in the anthroposcene[200] where the new metaphors of human interaction with nature are "messing with nature"[201] "tampering with nature"[202] "domination of nature"[203] and "playing God."[204]

Climate engineering will also have some negative impact on the aesthetic appeal of nature and environment such as the difference in the sunsets, loss of the blue sky, wilderness and naturality. This may be termed as the aesthetic argument against climate engineering.[205]Betz and Casean (2012) call it the "loss of intangible."[206] Holism arguments[207] and non-interference argument[208] are also coined against intentional climate change, which may be branded under the ecological objections. The point about holism argument is that the decision to geoengineer would imply our failure to adapt to nature. In our rapid expanding processes in terms of technological powers and population growth, we have failed in our ability to live in harmony with the rest of the creation, though humans are one of the recent arrivals in the evolutionary history.[209] Non-interference argument, as Paul Taylor has articulated, is that "we must not try to manipulate, control, modify, or 'manage' natural systems or otherwise intervene in their normal functioning.'[210]The respect argument holds that climate engineering indirectly points to the disrespect to nature because climate engineering was warranted by climate changes resulting from pollution which is a sign of our

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[200] Corner et al. 2013, p.940.
[201] Corner et al. 2013, p. 942.
[202] Gramstad and Tjøtta 2010, pp. 13, 15; Jamieson 1996, p.325.
[203] Gardiner 2010, p.288; Gardiner 2011, p.184; Hale 2012, p.22; Hamilton 2011b, p. 7.
[204] Pope John Paul II *Centessimus Annus*, IV, 37; WCC 1998; Hale 2012, p.22; Hamilton 2011a, pp.11-14; Hulme, p. 697; Ray 2010.
[205] Ott 2010a,b,d; Keith 2000a: 277 et seq.; Robock 2008a, Preston 2011, p. 460.
[206] Betz and Casean, p. 124.
[207] Gardiner 2010, p. 304; Jamieson 1996, p.332.
[208] Preston 2011, p. 463.
[209]See Gardiner 2010, p. 304.
[210] P. Taylor, *Respect for Nature* (Princeton, NJ: Princeton University Press, 1986), p. 175. See Preston 2011, p. 463.

disrespect for nature.[211] The respect argument extended to the non-human species[212] invokes animal liberationist perspectives and bio-centric perspectives in relation to climate engineering. As deep ecology is concerned with the relationship of humans to nature and the role of humans in the web of life, climate engineering concerns cannot stay away from sharing some platforms with it.

3.4 **Discussion**

In this section, we shall engage with the argument streams at a greater degree highlighting the various ambiguities of the argument clusters. After observing some of the general characteristics operative in the debate landscape, we shall move on to wider conceptual and thematic issues of the debate. Accordingly, this section is divided into two parts: logistical observations, and thematic engagement. By logistical observation we mean the general characteristics and commendable elements in the overall progress of the debate. In the section on thematic engagement, we shall dwell in detail on some argument frames, which deserve further attention and development.

3.4.1 Logistical Observations

3.4.1.1 The Complex Dynamics of the Debate Landscape

A review of the literature on the ethics of climate engineering at this stage of the debate is posed to encounter a series of difficulties. The plethora of ethical arguments with an interwoven and interdisciplinary nature pose the initial problem. The gestational phase of the empirical research and the lack of scientific clarity on the whole make the ethical assessment difficult. The degree of empirical uncertainty and the range of hypothetical openness to even contradictory positions present in most arguments make the assessments ambiguous. The expository and descriptive nature of most papers with qualified positions and selective endorsement of the arguments for or against, and conversely, the absence of a tangible and definitive endorsement or negation of concrete positions make the overall debate less articulate.

There seems to be little consensus in the literature on the demarcation between the purely scientific, social, political and ethical problems inherent in the controversy. Accordingly,

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[211] Hale 2009; Hale and Grundy 2009; Morrow et al. 2009, pp. 3-5.

[212] B.Hale, 2011; Hinding 2013, p. 3; Ben Minteer, "Geoengineering and Ecological Ethics in the Anthroposcene," *BioScience* 62 (2012): 857-858, p. 858; Morrow et al. 2009; Svoboda 2012b, pp.249ff; Svoboda 2012a; Tuana 2012, p. 139.

most scientific authors identify only a few ethical problems[213] in the climate engineering controversy, while the ethicists and philosophers are inclined to raise an ethical point on almost every aspect of the controversy. The scientific ambiguity and uncertainty opens up an unchartered territory to the ethicist to voyage into far-fetched analyses and apprehensions.

3.4.1.2 Semantic Diversity and Ethical Ambiguity

The ethical deliberation of climate engineering becomes complex on account of the differing focuses and applications of the very technology. The usage of the term climate engineering in the literature as referring to varying technologies poses a crucial challenge in the ethical appropriation of climate engineering.[214] Bellamy et al (2012) made a critical review of the various climate engineering proposals and they found that the substantial variability in the outputs of different proposals originated from the "hidden framing effects relating to contextual and methodological choices."[215] They claim that climate engineering has largely been appraised in contextual isolation, "ignoring the wider portfolio of options for tackling climate change – spanning mitigation and adaptation – and creating an artificial choice between geoengineering proposals."[216]

An example of the interplay between semantic ambiguity and ethics is present in the arm-the-future argument. Betz (2012), in his analysis of the arm the future argument in defence of sulphate aerosol climate engineering, found it to be objectionable and "far from invincible."[217] However, he concluded that the same argument "would face significantly less objections, if it were understood as an argument for developing carbon management technologies (such as, e.g., air capture or biomass to coal) rather than technologies for global albedo enhancement."[218] It shows the need for developing specific ethical discussions around technology-specific climate engineering. Betz (2012) rightly concludes: "the argument for climate engineering research is case sensitive; focusing on specific technologies might help to alleviate some of the objections such a research program faces."[219] According to Preston (2013), "the ethical concerns intensify or weaken depending on the technology under consideration. The wide range of climate engineering technologies currently being discussed

[213] Keith identifies only three ethical concerns and that too pragmatic in nature.
[214]See Chapter 2; 2.2.1.
[215]Bellamy et al. 2012, p. 1.
[216] Bellamy et al. 2012, p.1.
[217] Betz 2012, p. 474.
[218] Betz 2012, p. 474.
[219] Betz 2012, p. 484.

makes it prudent that each technique should be evaluated individually for its ethical merit."[220]It shows the technical complexity and the ethical diversity inbuilt in climate engineering debates. As Sheila Jasanoff (2003) states, "… it is a truism among policy scholars that the solution to a problem will only be as good as the framing of that problem."[221]

3.4.1.3 The Academic Lopsidedness of the Debate

Presently, the debate is somewhat confined to the academic circles, or, is in general "expert-analytic."[222] Though there is a good number of a grey literature sources (76 papers) apart from the peer-reviewed articles, popular publications on the topic seems insufficient. Need for more number of popular publications is important given the call for public engagement as underscored by several of the papers. It is noticed that even the grey literature is published in top class journals. The public in Asia and Africa seems to be poorly informed. There should be deliberate efforts by ethicists and policy makers to make the debate inclusive with representation from the different regions of the world who can do the moral philosophising from their own concrete context.

There seems to be regional prejudices with regard to climate problems. For instance, in India, there is the general impression generated by the media that climate change is mostly a problem generated by the affluent life style of the developed West, and therefore, to be resolved by them. However, the cataclysmic nature of the problem is such that no nation can take such a self-abdicating approach. "As an issue potentially affecting citizens of countries around the globe—both rich and poor—dialogue about the prospect of engineering the earth's climate should not be confined to technical or political elites, nor for that matter solely to the citizens of industrialized Western nations."[223]Bellamy et al. (2012) call for a balancing of appraisal methods, that, only with a "participatory-deliberative appraisals of geoengineering…. can we begin to fully account for the great systems uncertainties and high stakes that characterize the post-normal state in which the upstream science of geoengineering resides."[224] Bellamy et al. (2012) comment that "Most existing methods of

[220]Preston 2013, p. 23.
[221] Sheila Jasanoff, "Technologies of Humility: Citizen Participation in Governing Science," *Minerva*, 41, 3 (2003), 223-244, p. 240.
Banerjee 2011, p. 21.
[222] Bellamy et al. 2012, p. 1.
[223] Corner and Pidgeon 2010, p. 27.
[224]Bellamy et al. (2012); See also, S. Funtowicz, and J. Ravetz, Three Types of Risk Assessment and the Emergence of Post-normal Science," in S. Krimsky and D. Golding, Eds., *Social Theories of Risk* (New York: Greenwood Press, 1992): 251- 273.

appraisal do not adequately respond to the post-normal scientific context in which climate engineering resides and show a strong emphasis on closed and exclusive 'expert-analytic' techniques."[225]

3.4.1.4 Inadequate Interdisciplinary Engagement

As of now there are more professional philosophers and ethicists on the debate scene. It seems more involvement of the scientists will give greater credibility to the debate. Keith, Schneider, Robock, etc., are the leading scientists involved also in the ethical debate. The multifaceted nature of the problem spanning over the scientific, social, ethical, political, and economic terrains deserve greater attention in the debate. The debate seems to be lopsided, to some extent, towards the ethical and philosophical terrain with inadequate scientific information and participation.[226]

As we have seen already, though the debate was given a major kick off by Crutzen in 2006, the number of environmental scientists participating in the debate is far from sufficient. However, there is a progressive interdisciplinary attention seen in the field. As Banerjee (2011) observes, **"**Asilomar II was an improvement on Asilomar I because the second Asilomar attempted to bring together social and natural scientists, and to engage citizens in deliberation about geoengineering governance."[227] "A sound characterization of the underlying probabilities and risks requires a well-integrated analysis spanning fields such as Earth sciences, statistics, and economics…"[228] In climate engineering, "the ethical and economic analyses hinge critically on a (hopefully) solid foundation provided by the natural and social sciences."[229] Tuana's suggestion for developing an ELSI (Ethical, Legal and Social Issues) analysis is relevant in this context. Scott argues, "SRM is not merely an engineering puzzle. Responsible decision-making over SRM research and possible deployment will require cooperative and interdisciplinary discussions…. This presents a challenge for synthesizing the essential insights from various disciplines that must be involved in responsible decision-making on SRM."[230] Harnisch has shown the need for interdisciplinarity

[225] Bellamy et al. 2012, p. 1.
[226] The arm-the-future-argument, scrutiny of the research question as well as the double catastrophe argument could be counted under this observation.
[227] Banerjee 2011, p.30; Harnisch and Uther 2010, pp.6-7.
[228]Tuana et al 2012, p. 141.
[229] Tuana et al. 2012, p.141.
[230] Dane Scott, "Introduction to the Special Section, 'The Ethics of Geoengineering: Investigating the Moral Challenges of Solar Radiation Management,'" *Ethics, Policy and Environment* 15:2 (2012b):133–135, p. 134.

in risk calculation.[231] The how of interdisciplinary engagement in climate engineering constitutes a significant stream for the future advancement of the debate.

3.4.1.5 Missing Contextual Setting

Though there is a considerable awareness of the need for technique-specific appropriation of climate engineering ethics, the literature does not reflect the awareness of a context-specific and region-based analysis of the relevance of climate engineering. Though ethics is a contextually embedded discipline, there is no engagement at the contextual application of a particular technique and deliberations over its consequent contextually defined opportunities and challenges. As of now the literature seems to be handling mostly the merits or demerits of the global impact of climate engineering.

There is a general presupposition in the literature that nations more vulnerable to climate changes will support climate engineering. The strength or weakness of the ethical concerns is likely to be fluctuating relative to the context. For instance, the desperation argument critiqued by Gardiner has specificity. Desperation argument refers to a situation of climatic catastrophe where climate engineering may be rhetorically desired. It assumes that in a desperate context, if countries like Maldives initiate climate engineering or request the competent countries to save them through climate engineering, the dire urgency and desperate plea of the affected would provide a justification for climate engineering. It assumes that the pleas of the desperate would justify climate engineering. In other words, the danger of the catastrophe coupled with the fate of the vulnerable population would set aside the various apprehensions about climate engineering. Desperation thus becomes the justification for the policy making.[232] It is thus a variant of the lesser evil argument.

While we find the existing literature to be general and non-specific, we do not mean that the quality of the existing research is anything low. Our arguments subsequently in the normative chapters will be more along the same level of general statements as we are short of any exhaustive technology-specific analysis. We highlight the absence of specific ethical analysis of technology with a view to suggest the future directions for the debate to advance.

3.4.1.6 Ethics Precedes Technology

[231] Harnisch and Uther 2010, p. 3.
[232] Gardiner 2013b, p. 28.

Preston (2012) describes the ethics of climate engineering as something extraordinary.[233] The extraordinary aspects of the ethics of climate engineering may be identified in many respects. This is perhaps the first time in the history of the interface between technology and ethics that a potential technology that has not fielded any commendable field test yet, let alone developed a proper research protocol, has been subjected to such rigorous ethical scrutiny. Although there were instances of ethics preceding technology in several cases as in the proposals for human cloning, genetically modified food, and genetically modified organisms, advancements in research had made the technology a tangible scientific possibility in those cases.[234] Environmental scientist Gregg Marland's (1996) admission that "It is hard to focus on the 'could we' parts of the discussion without raising the 'should we'"[235] seems to place the question of the ethical desirability of the technology before the technical feasibility of the same.

It could also be noted that most papers dealing with the ethics of climate engineering have an open approach without a definitive negation or endorsement of climate engineering. Out of the 138 papers reviewed, arbitrarily judged, there seem to be only 10 papers, outright supporting climate engineering deployment and only five papers outright ruling out climate engineering.[236] Though the nod for research and development into climate engineering is dormant in several papers, the number of papers advocating research and development is limited to 15. Most authors wish to take cautionary and qualified positions. This qualified stand taken by most authors is likely due to the high degree of uncertainty hovering over the debate. This observation corroborates the need for alleviating the element of uncertainty in climate engineering debate.

3.4. 2 Thematic Engagement

3.4.2.1 Lesser Evil or Greater Evil?

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[233] Preston 2012, p. 1.

[234]We are aware of the observation that the ethics of climate engineering is something extraordinary is not non-contentious. For instance, GMO techniques like stress and salt tolerant GM crop varieties were claimed to be developed since the late 1980s but was never existent. However, climate engineering differs in terms of scale and outreach.

[235] Gregg Marland, "Could We/Should We Engineer the Earth's Climate," *Climatic Change*, 33:3 (1996), 275-278, p. 276.

[236] It is acknowledged that arbitrary and interpretative elements may be present in the classification of the papers along this line.

The lesser evil argument seems to be one of the moderately developed argument streams in the debate with a cluster of arguments supporting and opposing it. Two general impressions emerge from an overview of the lesser evil debate scenario. Firstly, the claim of lesser evil as a straightforward argument for climate engineering is deceptive and superficial as the proponents do not seem to have satisfactorily answered to the objections to lesser evil. Secondly, the recourse to lesser evil in the present phase of the debate seems to be relying heavily on philosophical premises than on scientifically legitimate propositions.

The lesser evil argument has the presumed assumption that mitigation and adaptation are the preferred options for tackling climate problems. It also assumes that climate engineering has inherent ethical problems and therefore to be considered as an evil though of a lesser degree, and this would be justified only in a do or die context. Gardiner (2010b) observes that "appeals to the lesser evil are attractive to a wide audience, including those who are otherwise strongly against technological intervention."[237] The major boost to climate engineering given by Crutzen dwelt on the lesser evil argument for the desirability of research into climate engineering.

The vulnerability of the arguments to be countered by the opposing position is perhaps best evidenced in the case of the lesser evil argument, whereby some of the opponents would treat it as a greater evil than a lesser one. There are intrinsic problems which are unsettled in treating climate engineering as a lesser evil. Although the proponents of climate engineering present lesser evil as one of the major arguments for justifying their position, there are several objections to this argument to which they have not responded convincingly. Is it ethically justifiable to develop a technology, with such a massive magnitude, which is considered an evil in itself? How reliable are the predictions of a nightmare scenario? This concern is probably the dormant motive behind the Royal Society's discontent with the last resort arguments.[238] Gardiner (2007) thinks that there are several questions that are not satisfactorily answered in treating climate engineering as lesser evil: "how likely is the emergency situation (where one has actually to decide between these two options) to arise? Is it true that these are the only alternatives? Is the lesser evil really lesser, all-things-considered? Now, as it happens, the answers to these questions seem very much in doubt in the geoengineering case."[239]

[237] Gardiner 2009, p. 3.
[238] See Gardiner 2011, pp. 178ff.
[239] Gardiner 2007, p. 2.

Unlike other emergencies, climate emergency is an anticipated emergency and the normal way to respond in such a situation is to take the measures to avoid the occurrence of the emergency.[240] There is the "important difference between preparing for an emergency and preparing for an emergency that is to be brought on by one's own moral failure"[241] which is typically the case with climate engineering. Preparation for emergency does not necessarily imply doing climate engineering. Rather, it can be a way of enhancing our mitigation strategies like developing alternative energy sources.[242]

Crutzen's proposal cannot be neutral as it would encourage "political inertia"[243] on mitigation and adaptation. The question of researching into climate engineering cannot be discussed in isolation from the issues of deployment.[244]The problem of "intergenerational moral corruption"[245] is necessarily inbuilt in opting for climate engineering as an insurance policy or Plan B, because if a future climate emergency, consequent of our political inertia, is a real possibility, we owe more to the future generations than climate engineering, like compensation.

Some arguments diametrically oppose the central assumptions of the lesser evil argument. Climate engineering is no lesser evil; rather, it might lead to an evil scenario worse than the emergency scenario resulting from political inertia with mitigation and adaptation.[246] The fear of this scenario cannot be underestimated given the mounting of the CO_2 concentration in the atmosphere, the sidelining of mitigation efforts, and the long-term side effects of climate engineering. The historical examples of the destruction of the societies like Mayan, Khmer and Old Kingdom of Egypt are indicators to the dangers of rapid climate changes.[247] A

[240] Gardiner 2007, p. 3.
[241] Gardiner 2007, p. 4.
[242] Gardiner 2007, p. 4. "[W]e could invest in alternative energy in order to prepare future people for a massive emergency deployment of alternative energy sources (e.g. by establishing a "Strategic Solar Panel Reserve"), or we could establish a massive international climate assistance and refugee programme, or we could do both of these things, together with any number of other alternatives." The feasibility of developing a massive "Manhattan Project" from cheap alternative energy could be considered (Gardiner 2009, p. 12). Bengtsson in his response to Crutzen's influential paper observed, "I do consider it more feasible to succeed in solving the world's energy problem, which is the main cause to the present concern about climate change, than to successfully manage a geo-engineering experiment on this scale and magnitude, which even if it works is unable to solve all problems with the very high concentration of greenhouse gases in the atmosphere." Bengtsson 2006, p. 233.
[243] The problem of political inertia, coined by Gardiner, refers to the slow progress with adaptation and mitigation (See, Gardiner 2007, p. 1).
[244] Gardiner 2007, p. 3.
[245] Gardiner 2007, p. 4.
[246] Gardiner 2010, p. 291; Betz and Casean 2012, p. 113.
[247] N.P Dunning, T.P. Beach, S. Luzzadder-Beach, Kax and Kol, "Collapse and Resilience in Lowland Maya Civilization," *Proceedings of the National Academy of Sciences* 109 (2012):3652–3657; B. M. Buckley,

dangerous climate scenario brought on by intentional climate change is morally still worse.[248] Similarly, the analogy of the sick-patient having to apply severe dosage of medicine is found incompatible in the climate engineering scenario, because there is no absolute bottom line in this case, whereas a sick patient would be dying eventually.[249]

Although the proponents of the technology have recourse to the maxmin principle, Betz's (2012) analysis shows the conditions of applying the maximin principle are not met in the case of climate engineering.[250] The application of the maximin principle in the lesser evil argument is contentious. Betz (2012) opines that the maximin principle can be applied equally for and against employing climate engineering research and development. A similar problem is faced by invoking the precautionary principle in defence of the lesser evil argument. The precautionary principle would be justified in the context of climate engineering if only the selective and interpretative variants of the principle are invoked. Contrary to the claims of the proponents in terms of the precautionary principle, Banerjee (2011) argues that "A strongly precautionary approach to geoengineering would ban all research, or impose a moratorium."[251] Research on climate engineering defended by lesser evil argument itself is unjustified, "since there is no 'practice planet' on which these technologies can be tested"[252]

The arm-the-future argument, a subset of the lesser evil argument, has its own moral problems and limitations. According to Gardiner (2010b), "… the argument obscures much of what is at stake in the ethics of geoengineering, including what it means to call something an 'evil', and whether doing evil has further moral implications."[253] Betz (2012), having recapitulated the pluralistic aspects of the arm-the-future argument and the objections against it, concludes that "the case for climate engineering research can be recast, by making provisions or concessions, so as to take the criticism into account and to ease the opposition between the conflicting positions."[254] Betz (2012) continues, "proponents and opponents of the AF-argument differ with respect to the assessment of our future ability to reliably predict

K.J.Anchukaitis, D. Penny, R. Fletcher, E. R.Cook, M. Sano, and L. C. Nam, "Climate as a Contributing Factor in the Demise of Angkor, Cambodia," *Proceedings of the National Academy of Sciences USA* 107 (2010): 6748–6752; K. W. Butzer, "Collapse, Environment, and Society," *Proceedings of the National Academy of Sciences* USA 109 (2012):3632–3639. See also, Baum et al., p. 7.

[248] Betz and Casean 2012, p. 114; Gardiner 2010, p. 304.

[249] Betz and Casean 2012, p. 115

[250] Betz 2012, p. 482.

[251] Banerjee 2011, p. 27.

[252] Scholte et al. 2013, p. 4.

[253] Gardiner 2009, p. 3.

[254] Betz 2012, p. 483.

the earth system. While proponents are optimistic about pushing the current limits of social and natural sciences, opponents point out that we might not gain the detailed understanding necessary for accurate climate engineering predictions."[255] On a detailed analysis of the assumptions upon which the lesser evil argument is founded, Gardiner (2010b) has identified a number of areas that may run against the justification offered by lesser evil argument for climate engineering.[256] Gardiner (2010b) concludes that its narrow focus would be tantamount to moral corruption.[257]

On the whole the treatment of the lesser evil argument in the literature shows a high degree of philosophical maturation. However, the argument relies heavily on the speculative methods with inadequate scientific backing for the philosophical positions.

3.4.2.2 The Strategic Positioning of Climate Engineering

In the present phase of the debate, the literature in general is vague about the strategic level at which climate engineering is debated upon. Some methodological refinement might alleviate, to some extent, some of the complexity and ambiguity prevailing over the overall debate. A systematization of the complex argument frames in terms of the position attributed to climate engineering among the various strategies to combat climate change might provide a straightforward framework for policy makers in their assessment. Clarifying the status of climate engineering is of foundational importance for subsequent development of the debate. By strategic positioning, we mean the ranking of the climate engineering technology among the various strategies to address the climate change. In most papers, there is some hidden framing of the status of climate engineering, treating this technology either as "the best option" - Plan A - , or, as a Plan B - a supplementary tool facilitating the efforts of mitigation and adaptation - as a possible insurance policy, or as a last resort option. Understanding the ranking order of climate engineering among the various means to combat climate change would help formulate precise and right questions of varying ethical intensity. For instance, there is a significant difference between the questions, is climate engineering desirable and is climate engineering desirable as the best option?, or, is climate engineering justifiable as a

[255] Betz 2012, p. 478.

[256] Gardiner states that "in general, we should not simply accept as a stipulation that some policy is said to be an evil (like geoengineering) should be endorsed because under some circumstances it would be lesser evil than some other policy (such as allowing a catastrophic climate change). Instead, we should ask important questions such as: How likely is this emergency situation ... to arise? Is it the most relevant emergency situation? Is it true that the two evils are the only alternatives? Is the lesser evil really lesser, all-things considered?" (Gardiner 2009, p. 10).

[257] Gardiner 2009, p. 19.

Plan B, or, is climate engineering justifiable as a last resort? These questions vary significantly in their moral value. Therefore, the proper placement of the climate engineering approaches in the graded hierarchy of the measures to combat climate change is necessary. Depending on the ranking of climate engineering in the hierarchy of the climate change combating measures, the strength or weakness of the arguments for and against climate engineering will be significantly varying. For instance, the tangibility of the moral hazard objection will be weakened if climate engineering is presented as a supplementary tool to mitigation and adaptation, and conversely, any hubristic hype about it as the best option might reasonably aggravate the case of moral hazard.

It is not overlooked that there are a couple of hard-core champions of climate engineering who treat it as the first option and so too some others on the other side of the aisle ruling out climate engineering, whatever status it may be given. With some interpretative discernment, at least 7 works may be classified as having a strong orientation to climate engineering as a preferred option.[258] In addition, a minimum of dozen authors would strongly advocate research and development at this stage.[259] In addition, there are many other proponents and stakeholders of climate engineering among scientists, environmentalists and economists, like Novim Group, Copenhagen Consensus Centre, American Enterprise Institute, Institution of Mechanical Engineers, Stewart Brand, James Lovelock, Mike MacCracken; private entities like Climos, Planktos, Bill Gates, David Victor, Scott Barret, Alvin Lin; and Royal Society scientists like John Shepherd, David Keith, Peter Cox, Ken Caldeira, etc., who are cautious but vehement champions of climate engineering.[260] The Arctic Methane Group also calls for the actual deployment of the technology.[261]

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[258] The following authors consider geoengineering as a preferential choice. Michaelson 1998; David W. Keith, "Engineering the Planet," in Schneider et al. eds., *Climate Change Science and Policy* (Washington: Island Press,2000b): 494-502; William Nordhaus, A Question of Balance: Weighing the Options on Global Warming Policies (New Haven: Yale University Press, 2008); William D. Nordhaus & Joseph Boyer, *Warming the World: Economic Models of Global warming* XII (Cambridge, Massachusetts: MIT Press, 200); See also its review,J. Fost, Review: Warming the World: Economic Models of Global Warming by W. D. Nordhaus and J. Boyer, Journal of Economics 77:1 (2002): 94-98; Deepak Lal, "*Eco-Fundamentalism*," International Affairs 71:3 (1995): 515-528; Edward Teller et al., *Active Climate Stabilization: Practical Physics-Based Approaches to Prevention of Climate Change*, Lawrence Livermore National Laboratory, Apr. 18, 2002, at 1, 4, *available at* http://www.osti.gov/accomplishments/documents/fullText/ACC0233.pdf.] (See also Davies 2011, p.102, Footnote No. 4).

[259] Goodell 2010; C. Greene et al. 2010; Parkinson 2010; Rayner 2011; Royal Society 2009; Virgoe 2009; Cicerone 2006; Crutzen 2006.; Hinding 2013, p.3. Robert B. Jacson, "Pursuing Geoengineering for Atmospheric Restoration," *Issues in Science and Technology* Summer (2010):67-76; MacCracken 2006, p. 241; Schneider, 2008; Davies 2011.

[260] See Banerjee 2011, p. 19.

[261] See Gardiner 2013b, p. 28.

Understandably, there is a pragmatic preoccupation with the outspoken proponents of climate engineering. A sort of pragmatic reductionism with the ethical concerns is evident in the best option argument. They seem to be approaching the controversy from a practical point of view overriding the wider philosophical and ethical nuances of the debate. In fact, as for Keith, the objections to climate engineering are only pragmatic problems. Hamilton (2011a) criticizes such an approach: "One implication of the best-option argument is that it implies that the ethics of climate engineering can be reduced to a disagreement over scientific and economic facts. An important philosophical aspect of this utilitarian position is that it rejects the view that motives count when making ethical judgments. Those who adopt this approach see themselves as pragmatic—what matters, practically and ethically, is what works."[262] The pragmatists in the debate need to fill up the ethical gaps - ignoring the wider nuances of the problem - in their assessment by engaging with the hardcore opponents of it. As of now, the status of climate engineering as "the best option" seems an overstated and frivolous claim.

Many papers assume a complementary status for climate engineering. In this approach, climate engineering forms synergies with mitigation and adaptation in tackling climate change.[263] More research and study is to go to assessing the pros and cons of climate engineering exercised in combination with mitigation. Some selective studies in this field have highlighted some of its merits. Gramstad's estimation of the combined cost-benefit analysis of climate engineering with mitigation pin points the new directions opened by up such synergies: "Combining climate engineering and emission control increases the net benefit even further to 4.3 – 18.0 trillion US dollars…"[264] Yet another fruit of such a synergy which might dispel several ethical anxieties is seen in the optimism of Lenton and Vaughan (2009): "[s]trong mitigation, combined with global-scale air capture and storage, afforestation, and bio-char production, i.e. enhanced CO_2 sinks, might be able to bring CO_2 back to its pre-industrial level by 2100, thus removing the need for other geoengineering."[265]

A third position differentiated from the other approaches is the outright negation of the climate engineering proposals.[266] For Burns (2012), even contemplating about such

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262 Hamilton 2011a, p. 3.
263 See, MacCracken 2006, p. 241; Amelung 2012, p. 41; Wiertz 2012, in Amelung et al. 2012; Goodell 2010, p. 21; Greene et al. 2010, 22; Natural Environment Research Council (NERC): *Experiment Earth?* Report on a Public Dialogue on Geoengineering, August 2010, p. 41. Available at http://www.nerc.ac.uk/about/whatwedo/engage/engagement/geoengineering/geoengineering-dialogue-final-report/. Accessed on January 21, 2015; Royal Society 2009.
264 Gramstad and Tjøtta 2010, p. 12.
265 T. M. Lenton & N. E. Vaughan 2009. See also, Banerjee 2011, pp. 16-17.
266 D. G. Victor, M. G. Morgan, J. Apt, J. Steinbruner, and K. Ricke, "The Geoengineering Option: A Last Resort Against Global Warming?" *Foreign Affairs* (April 2009). Available at

technological employment is "… paradoxical, and perhaps even a bit tragic …"[267] Some authors and groups will be inclined to think along with Rapp (1989) that "it is easier and safer to stop before getting started."[268] They question the very desirability of research programs, asking, "should we even begin serious, sustained research programs?"[269] For them climate engineering is no option at all.

A fourth perspective on the status of climate engineering often coined in the literature is to treat it as a last resort option. This perspective has been predominant in the lesser evil argument for climate engineering and is already mentioned in the preceding results and discussion. A study on the media attention on climate engineering covering 93 world newspapers from 1990 to 2010 identified "catastrophic" as the most common narrative frame. This is presented as a way to "save" the earth.[270] Nerlich and Jaspal (2012) did a metaphor analysis covering 91 newspaper articles. They concluded that "metaphors, analogies and arguments were mainly used to frame geoengineering as a last resort technology that has to be adopted in a context of impending catastrophe."[271] As discussed above, Royal Society has deliberately tried to downplay the last resort tone of climate engineering.

A final approach that may be called the neutral approach, considers it premature and immaterial to support or oppose climate engineering at this point. This approach is well captured in Gardiner's response, "unhelpful distraction"[272] to questions on support or rejection of climate engineering. This approach seems to be dominant among the leading ethicists in the field like Gardiner, Preston, Svoboda, and many others.

A random assessment of the various approaches to climate engineering in regard to its strategic positioning gives the impression that given the huge amount of uncertainties and ambiguities prevailing over the debate, the extreme perspectives of outright negation as well as the best option claim cannot be easily accepted as they are short of objective and verifiable evidences, especially since most climate engineering speculations are still confined to computer simulations. Clarifying the normative status of climate engineering as the best option (Plan A), or as a complementary tool (Plan B), or as the last resort option (lesser evil)

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http://www.foreignaffairs.com/print/64829. Accessed April 17, 2014; Robock et al. 2010; ETC Group 2009; Burns 2012; Bunzl 2009; B. Hale 2009; Seth, p. 2, 13.

[267] Burns 2012, p. 283.

[268] F. Rapp, "Introduction: General Perspectives on the Complexity of Philosophy of Technology," in P. T. Durbin (ed.), *Philosophy of Technology: Practical, Historical, and Other Dimensions* (Dordrecht, Boston: Kluwer Academic Publishers, 1989): pp ix–xxiv, p. xx.

[269]Keith *et al*. 2010, in Scott 2012a, p. 2.

[270] See, Scholte et al. 2013, p. 4.

[271] Nerlich and Jaspal 2012, p. 143.

[272] Gardiner 2013b, p. 28.

and aligning the debate along this ranking would bring greater clarity to the overall debate. Inasmuch as the technology-specific ethical deliberation is helpful for the debate, the position-specific debate also would be as much helpful for alleviating the complexity and ambiguity prevailing in the debate.

3.4.2.3 Asymmetric Focus on SRM over CDR

Ethical deliberations have focused more on SRM than on CDR technologies. This is evident from the results from the first round search as described in the methodology. While the first round of search with SRM in the title combined with a set of combination words produced 6 results, the similar search with CDR in the title produced no results. In the final search results, 16 papers[273] are identified with an exclusive focus on the ethics of SRM; whereas there was not a single paper with the exclusive discussion of the ethics of CDR, barring three papers[274] with some selective focus on ocean fertilization. An international workshop held at the University of Montana in October 2010 had the specific theme, "The Ethics of Geoengineering: Investigating the Moral Challenges of Solar Radiation Management." The emphasis on SRM also explains why the exit problem – the problem of terminating the aerosol injection abruptly - became excessively predominant in the arguments against literature with 17 papers sharing this concern. In the literature, the ethics of CDR technologies is discussed mostly in combination with the climate engineering technologies in general.

The emphasis on the ethics of SRM and the discard of the CDR ethics seem premature, and perhaps, an unhelpful deviation too. As of now, there is no imposing scientific support for SRM technologies to be treated as the state of the art form of climate engineering. As Keith et al. has acknowledged, "To date, no geoengineering proposal has been researched to the point of becoming a policy option."[275]Rather, there are differing scientific voices of the Royal Society and IPCC with a preferred choice for the CDR techniques over SRM for climate engineering researches to take off. IPCC has recommendation for biomass technique, a subset of CDR techniques. In a study engaging the public in a series of discussion groups

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[273] Heyen 2012; Preston 2012; Baum et al 2013; Burns 2010; Crutzen 2006; Egede-Nissen 2010; Marlos Goes 2010; Mike Hulme 2009; Keith 2010a; Keller 2007; Long and Winickoff 2011; Macnaghten and Szerszynski 2013; Preston 2013; Scott 2012b; Patrick L. Smith, Leslie A. Wickman, Inki A. Min, and Steven M. Beck, "Feasibility of Space-Based Monitoring for Governance of Solar Radiation Management Activities," (2010). American Institute of Aeronautics and Astronautics. Available at http://arc.aiaa.org/doi/pdf/10.2514/6.2010-8767; *Patrick Taylor Smith, "Redirecting Threats, the Doctrine of Doing and Allowing, and the Special Wrongness of Solar Radiation Management,"* Ethics, Policy & Environment17:2 (2014): 143-146; Svoboda et al. 2011. In addition, the Preston's edited work, *Engineering the Climate – the Ethics of Solar Radiation Management*, has 13 papers precisely on the ethics of solar radiation management.

[274] Hale 2012; Hale 2009; Williamsona et al. 2012.

[275]Keith *et al*. 2010. Cited in Scott 2012a, p. 2.

held in 2010, titled ‘Experiment Earth?’[276]serious concerns over the safety of SRM methods were raised and a strong preference for more mitigation exercises was expressed.[277] The same study also showed the inclination among the people to support CDR techniques over SRM techniques.[278] Possibly, the emphasis on the SRM is caused by the trend-setting paper by Crutzen in 2006 recommending sulphate aerosol injection which accelerated the ethical discussion on climate engineering.[279]

It is widely acknowledged that there are significant differences between SRM and CDR in terms of side-effects, cost, and varying feasibilities at the scientific, political and social levels. For example, CDR techniques are said to be very expensive whereas SRM is considered to be "cheap, fast and imperfect."[280] Therefore, any general ethical assessment of climate engineering cannot be assumed to subsume the full ethical implications of the CDR technologies. As we have seen in chapter two, the different CDR techniques have totally different range of applications and their impacts and side-effects are significantly different. Much of the assessments of their consequences are still at the speculative level providing only inadequate scientific data and inconclusive results for ethical judgements.[281]It looks the climate engineering ethicists need to do more CDR-specific exercises for striking a balance in the debate, which is dominated by SRM-specific discussions.

Now, it is clear that the predominant question here is, how to proceed? Do we wait for reliable data or go for a moratorium on research and development? We feel that this question is to be left open at this phase of the debate. Although the precautionary principle can be invoked here as a tool to make a decision under uncertainty, it does not seem to resolve anything and the proponents as well as the opponents are using it to advocate their case. As decisions are often made in a context, we will have to speculate over and compare the various cases emerging from the intervening and non-intervening scenarios to make a more reliable way out. Such decisions under uncertainty do not seem to be adequately solved in applied ethics. As there are no clean solutions at the moment, this topic itself might be a subject of more rigorous research.

3.4.2.4 Climate Emergency – Consensus and Ambivalence

[276] See Ipsos-MORI, 2010, in Corner et al. 2013, p. 941.
[277] See, Corner et al. 2013, p. 941.
[278] See Ipsos-MORI 2010, in Corner et al. 2013, p. 941.
[279] Crutzen 2006.
[280]Keith *et al*. 2010. Cited in Scott 2012a, p. 2.
[281]See Chapter 2, 2.4.1.

The primary argument for climate engineering with the maximum support of papers as evident from the results is the climate emergency argument with 51 papers backing it. The overall landscape of the debate related to the various aspects of the climate change seems to warrant further scientific refinement. In the debate, unlike the other argument streams, there seems to be no serious objections to the scientific assumptions of climate emergency. The debate seems to be sharing a broad consensus on the dangers of climate change. The debate seems to pay no serious attention to some of the still grey areas in the science of climate change, though they are borderline voices. The proponents of climate engineering need to provide greater clarity on the elements of uncertainty and the lack of scientific consensus on some of the climate change estimations in order to make their arguments rock solid.

The proponents of climate engineering want climate engineering in order to save the earth against an imminent climate emergency. As for some, "a point of no return … may be as soon as 2015."[282] According to the majority of the scientists and policymakers, a temperature rise by 2ºC from pre-industrial period will have a serious impact on human institutions and ecosystems.[283] For Michaelson (1998), the catastrophic strategy is inevitable: "Not even the most austere post-Kyoto regulatory regime can avert a probable temperature rise of 2 to 3 degrees Fahrenheit during the next century…."[284] Gardiner (2013c) comments that "…the mesmerizing force of the emergency rhetoric"[285] is used as a coverage for the political and ethical issues in climate engineering.

However, there are areas which need greater scientific clarity in this regard. Firstly, there is the problem of defining what a climate emergency is. As Prantl (2011) has observed, "How would we define 'climate emergency' for the purpose of triggering the deployment of geoengineering technology?"[286] The various scientific opinions on climate change weaken the credibility of the predictive potentials of such projected emergencies. A consensus on

[282] K. Anderson, & A. Bows, "Reframing the Climate Change Challenge in Light of Post-2000 Emission Trends," *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* (2008): 3863-3882. Available at http://rsta.royalsocietypublishing.org/content/366/1882/3863?wptouch_preview_theme=enabled, accessed April 5, 2015.
[283] German Advisory Council for Global Change, *New Impetus for Climate Policy: Making the Most of Germany's Dual Presidency,* WBGU Policy Paper 5 (2007); Comm'n of European Cmtys., *Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, Limiting Global Climate Change to 2ºC the Way Ahead for 2020 and Beyond* (October 1, 2007); James Hansen et al. *Dangerous Human-Made Interference with Climate: A GISS Model Study,* 7 *Atmospheric Chemistry & Physics* (2007):2287-2312. *Available at* http://pubs.giss.nasa.gov/docs/2007/2007_Hansen_etal_1.pdf. See Burns, 2011, p. 38. Accessed on April 3, 2014.
[284] Michaelson 1998, p. 4.
[285] Gardiner 2013b, p. 28.
[286] Prantl 2011, p. 4.

tipping points, climate thresholds, etc., may be far from near. Secondly, though the dangers of climate change is pretty clear and there is a broad scientific consensus on this point as reflected in the IPCC's reports, there are some borderline environmental groups that hold that climate change is a pseudo problem. Thirdly, the anthropogenic reasons for the climate change are also contented by some others. The "sceptical environmentalists" or "deniers"[287] downplay the challenges posed by climate change.[288] The sceptics challenge the reality of global warming, negate its anthropogenic grounds, and question the predictions about its impacts.[289] Fourthly, there is the marring of the debate on climate change by political and economic interests.[290] In the present day climate science, the element of subjectivity is no pseudo-issue. For instance, as Nordhaus (2009) puts it, "… the perception of risk under present (climate) circumstances is highly subjective."[291]

Probably, it is because there is almost a universal scientific consent on the climate emergency that the doomsday prophets of climate engineering do not seem to engage seriously with the borderline objections to climate changes, nor with the subtle nuances of the climate emergency claims. The comparatively high average of papers dealing with the elements of uncertainty, especially uncertainties in regard to climate changes and climatic impacts, are further a case against overlooking the loopholes in the claims of climate emergency. The debate scenario seems to remain inconclusive for a watertight, evidence-based justification of the climate emergency calling for climate engineering. Climate emergency arguments need further sophistication in its various nuances.

3.4.2.5 Conflict of Interest

A dynamic of the debate that might prove to be crucial in the future, but underdeveloped in the present setting of the debate pertains to the hidden epistemological quandaries. Possible conflict of interests, potentials for moral corruption, and the unhindered progress motive are a few such factors randomly mentioned in the debate. Although these concerns find some off-the-cuff mention in some authors, they are not dwelt upon to their deserving proportions.

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[287] The phrases are of the ETC Group 2012, p. 220.
[288] See ETC, 2012, p. 220.
[289] See A. Dessler, E. Parson, *The Science and Politics of Global Climate Change: A Guide to the Debate* (Cambridge, UK: Cambridge University Press, 2006). R.W. Spencer, Climate Confusion: How Global Warming Hysteria Leads to Bad Science, Pandering Politicians and Misguided Policies that Hurt the Poor (New York: Encounter Books, 2010); J. Tollefson, "Climatic-change politics: The Skeptic Meets his Match," *Nature* 475 (2011): 440–441; C. Mooney, *The Republican War on Science* (New York: Basic Books, 2005).
[290] See Resnik and Vallero 2011, p. 5
[291] W. D. Nordhaus, "An Analysis of the Dismal Theorem," (2009). Discussion Paper, New Haven, Connecticut: Cowles Foundation for Research in Economics, Yale University. Available at http://cowles.econ.yale.edu/P/cd/d16b/d1686.pdf. Accessed October 1, 2015.

Many leading climate engineering scientists who are influential figures in policy-making are involved in more than one research project including those initiated by private companies, or funded by private agencies. This might lead to a conflict of interests with the neutral scientists. According to Egede-Nissen (2010), this would press for the question, “Are scientists merely impartial providers and interpreters of vital information that we need in order to evaluate the advantages and drawbacks of geoengineering, or are they using their specialized knowledge and privileged positions to promote conclusions and solutions based on personal values and beliefs?”[292] Hamilton (2011a) warns, “A lobby group of scientists and investors is beginning to form and it is likely to become more influential as geoengineering becomes normalised in the public debate….”[293] In addition to the possible commercialization of the technology, an argument raised against climate engineering by several papers, the commercialization of knowledge itself might be at stake in the absence of a governance mechanism at the moment and in the context of the lead given by several private companies in the research. The loss of trust in science by the public has been on the rise in recent decades for several reasons[294] and this might be aggravated by the climate engineering controversy. Gardiner’s (2010a) warning on moral corruption[295] whereby moral discourse is subverted by personal motives shares the same fear. The fear of technology being used for military purpose and the likelihood of the commercialization of technology, as expressed by a significant number of papers, may also be correlated with it.

The couple of slippery slopes at stake in the debate also share some borderlines with these concerns with conflict of interests. The slippery slope that research might lead to deployment, as discussed in the results section, may be facilitated by the collective social mind-set not to oppose development, posing another uncritical epistemic barrier to an objective assessment of the controversy. The formation of interest groups is another concern. As Morrow et al. (2009) put it: “Perhaps the most worrying issue at this early stage is that the initiation of serious SWCE (short wave climate engineering) research would create interest groups that have strong incentives to continue SWCE research and even implementation. … (T)hese groups would resist efforts to abandon SWCE research, and they might push for SWCE implementation even if it proves to be unwise.”[296] Therefore, climate engineering

[292] Egede-Nissen 2010, pp. 2-3.
[293] Hamilton 2011a, p. 11.
[294] B. Barber, “Trust in Science,” *Minerva25*(1987):123-134; J. Ravetz, “What is Post-normal Science,” *Futures* 31 (1999): 647–653.
[295] Gardiner 2010, pp. 286, 291.
[296] Morrow et al. 2009, p. 9.

ethicists will have to pay greater attention to the likely deviations in the debate trajectory in future by the conflicting interests.

3.4.2.6 Public Engagement

The concern with the procedural propriety, characteristic of any ethical debate, is already raised in the climate engineering context as well. There is a strong call for the procedural propriety of policy-making by ensuring the pubic engagement with a bottom-up approach. However, the concrete instances of having engaged the public in the actual debate so far are only very nominal with a very few reports. The need for involving the sections of the society who are most vulnerable to the dangers of the technology is not emphasized. Although the Oxford principles have a strong blend along this line, it is strange that the Oxford principles have not captured a serious attention in the debate except for a few off the cuff mention by some authors. Besides, there is the challenge of undoing the catastrophe-mesmerism already created by the framings of the media. The issue of informed consent, central to research ethics, meets with unprecedented challenges in this case. Bodansky (1996) has commented that meeting the parameters of informed consent in climate engineering may be more difficult than working out a green house gases reduction treaty.[297] However, the proponents for tackling this problem have proposed no tangible framework or working hypothesis. These concerns are to be duly developed for the maturation of the debate to decisive levels.

The public engagement exercises already conducted in some countries have revealed that the public's knowledge of climate engineering is very poor[298] and the awareness of the danger of climate change creates a favourable attitude towards climate engineering.[299] The Ipsos-MORI study in 2010, has shown the inclination among the people to support CDR techniques over SRM techniques.[300] The positive correlation between the more individualistic worldviews of the subjects and the support for climate engineering, as shown by a number of studies,[301] itself constitutes a lot food for reflection from a critical epistemic point of view. While on the one hand, the public is open to researching climate engineering, they have reservations against its deployment. This is shown by the quantitative and qualitative data provided by the studies.[302] In the Experiment Earth study mentioned-above,[303] serious

[297] Bodansky 1996.
[298] Corner et al. 2013, p. 941.
[299] Pidgeon et al., 2012; Corner et al. 2013, p. 941.
[300] Ipsos-MORI 2010, Corner et al. 2013, p. 941.
[301] Bellamy and Hulme, 2011; Kahan et al., 2012; Corner et al. 2013, p. 941.
[302] Mercer et al., 2011; Corner et al. 2013, p. 941; and Ipsos-MORI 2010; Pidgeon et al. 2013; See also Macnaghten and Szerszynski 2013; Corner et al. 2013, p. 941.

concerns about the safety of SRM methods were raised and a strong preference for more mitigation exercises was expressed.[304]

Though a lion's portion of the controversy is reserved for the debate on researching climate engineering, some of the important principles of research ethics like respect and non-maleficence have found only a passing mention in the debate. A rapprochement between the climate engineering ethics and the traditional principles of research ethics is almost absent in the literature. The question of justice is given due importance. However, other principles like respect, benevolence and non-maleficence have not found deserving inroads onto the mainstay. The scope of such principles in climate engineering is described by Morrow: "The Principle of Respect requires that the scientific community secure the global public's consent, which would need to be voiced through their representatives and given for any studies within specified parameters, rather than on a case-by-case basis. The Principle of Beneficence and Justice requires that researchers strive for a favourable risk–benefit ratio and a fair distribution of risks and anticipated benefits, all while protecting the basic rights of the individuals affected. Finally, the Principle of Minimization requires that no study last longer, cover a greater geographical extent, or exert a greater influence on the climate than is necessary to test the specific hypotheses in question."[305]

Corner et al. (2013), exploring the "naturalness" of climate engineering techniques as perceived by the public, showed that there are hidden framings operative in considering something as natural. The hidden parameters can unintentionally condition the argument frames. As Corner et al. (2013) comment, the perception of some technologies as natural by the participants may be due to the simplistic framing of the facilitators. The analogies like artificial trees for capturing CO_2 and volcanic eruption to the release of sulphur particles into the stratosphere can do the tricks with framing.[306] Corner et al. (2013) comment that, "While these characterizations might be technically accurate, they also provide a powerful framing: that the way to think about these technologies is by analogy to existing 'natural' processes."[307]

Climate engineering debate needs to develop proper methodologies and tools or engaging the public in an objective manner, upholding the principles of research ethics, in an environment not conditioned by hidden framings.

303 Ipsos-MORI 2010, Corner et al. 2013, p. 941.
304 See, Corner et al. 2013, p. 941.
305 Morrow et al. 2009, p. 7.
306See Corner et al. 2013, p. 941.
307 Corner et al. 2013, p. 941.

3.4.2.7 Governance and Ethics

In the literature, there is an extensive discussion on governance in its multifaceted aspects. This was evident in the results shown up by the search methodology itself. In the first search, the combination of "governance" with the primary search words produced the most number of results, i.e., 30 hits. This is a considerable hike from the other results. It could be noticed that the combination of "ethics" with the primary search words, had only 17 results, the second highest. For the Royal Society (2009), the central problem in climate engineering pertains to governance. "The greatest challenges to the successful deployment of climate engineering may be the social, ethical, legal and political issues associated with governance, rather than scientific and technical issues."[308]

The strong emphasis on governance from the early days of debate shows that the think tanks and policy makers have fully captured the complexity of the governance. Despite the emphasis on governance, the debate is yet to produce any concrete and tangible form of governance, let alone a new international law, and the deliberations in the literature are still confined to the levels of suggestions, recommendations and models. The overemphasis on governance at this early phase and the identification of governance as the most serious issue seem to betray the same pragmatic approach to climate engineering coined by the hard core proponents, making it more a political and legal concern, over its ethical and social complexities. Even in papers on governance, the focus is mostly on the international, managerial and political aspects of it and in many papers it is not directly clear why governance becomes an ethically relevant question. Though there are ethically strong issues like the questions of moral authority, respect for sovereignty, etc., discussed by a number of papers, no paper has substantively engaged with them forming the primary focus. Hence, there seems to be a paradoxical situation that despite the heavy emphasis on the governance issues, the ethical aspects of governance remain underdeveloped.

Need for diverse governance models, scientific apprehensions against excessive governance, and recommendations of technique-specific governance are some of the leading streams forming the governance debate. True to the trans-boundary range of the climate engineering techniques, there is a broad consensus in the debate on the international nature of the governance mechanisms. There are arguments that different methods of governance are

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[308] Royal Society 2009, p. xi.

required.[309] There are also apprehensions against too much governance.[310] "Scientists engaged in geoengineering research have argued vigorously against any early regulation of their activities, insisting that society should take a hands-off approach until there is a risk of significant harm from tests and experiments."[311] The existing international governance structures are found inadequate and recommendations for structural adaptations in international governance to address the problem of climate change are also made. Treaty Approaches (UNFCCC, London Convention), Voluntary code based approach (Asilomar 2010), Environmental Assurance bonds model, Technologies of Humility,[312]*ad hoc* principles,[313] or via formal rules[314] governance at the multilateral level[315] or as a subset of countries[316] with current levels of technological capability, etc., are some of the models proposed.[317] Parthasarathy et al. (2010) highlight the flaws in a top-down approach and advocates a bottom-up approach.[318] Parthasarathy et al. (2010) consider the KPM (Keith, Parson, Morgan) approach which advocates loosely coordinated international program for Arctic Geoengineering to be "one of the most thoughtful approaches to date."[319] International governance models could include CLRTRAP(Convention on Long-range Transboundary Air Pollution), Montreal Protocol, ENMOD, IMO(International Maritime Organisation), UNEP (United Nations Environment Programme), UNFCCC, CBD (Conservation of Biodiversity), etc.[320]

The semantic ambiguity in regard to climate engineering is also to be considered in the governance question. The sort of governance is relative to the mode of technology used. For instance, "… air capture does not have the same accompanying governance concerns that SRM does."[321] The Royal Society has commented that scientific metrics alone are insufficient for governance.[322]

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309 Bracmort and Lattanzio 2013, p. 22.
310 Bracmort and Lattanzio 2013, p. 8.
311 Hamilton 2011a, p. 11. See, Morgan and Ricke, "Cooling the Earth Through Solar Radiation Management." The 2010 Asilomar Conference of geoengineering researchers was held to develop a set of voluntary guidelines. Available at https://www.irgc.org/IMG/pdf/SRM_Opinion_Piece_web.pdf. Accessed April 27, 2015. See, Alexis Madrigal, "Climate Hackers Want to Write Their Own Rules," *Wired*, March 23, 2010. Available at https://www.wired.com/2010/03/geoengineering-asilomar. Accessed April 27, 2015
312 Banerjee 2011, p. 21.
313 Victor 2008, Victor et al., 2009; Keith 2010.
314 Virgoe 2009.
315 Lin 2009; Berg, 2011.
316 Benedict, 2011.
317 Ghosh, pp.1-2.
318 Parthasarathy et al. 2010; pp. 5, 13.
319 Parthasarathy et al. 2010, p. 6.
320 Ghosh, pp. 5-6.
321 Banerjee, p. 17.
322 Royal Society 2009.

The climate engineering governance mechanisms must reflect the complex ethical nature of the controversy. Climate engineering ethicists should further develop the specific ethical concerns in governance issues. Further, the limited focus on the ethics in the discussions on governance needs to be rectified. For instance, as Gardiner has noted, the Royal Society has less than a page for ethics in its formal report on the science and governance of climate engineering. As of now, the review shows that the governance issue is debated by climate engineering scientists. No paper on governance seems to suggest the representation of the ethicists on the governance body. Therefore, the picture of the present review implies that that future course of developments in the debate needs to bridge the chasm between the huge ethical challenges of the controversy on the one hand and the absence of due ethical awareness in the governance concerns.

3.4.2.8 The Ethical Primacy of Side-effects

Yet another underdeveloped aspect of the debate, which has equal ethical and scientific overtones, is the issue of the side-effects. The future course of the debate needs to focus more on assessing and weighing the ethics of side-effects in a scientifically informed manner. While the proponents consider the side-effects to be negligible, it evokes some of the most furious hue and cry against climate engineering from the opponents. Many of the arguments centred on the side-effects still seem to be occurring in the abstract with less concrete assessment. Perhaps, the issue of side-effects was to top the list of the arguments with most number of cross-cutting subsets and clusters of arguments and counter arguments. The present state of engagement with the ethics of side-effects does not reflect a particular effect-specific assessment in its scientific, climatic, social and political aspects. In this regard, we agree with Betz and Casean (2012): "Weighing side effects represents common issues that occur throughout the CE (climate engineering) controversy. The proponents of the controversy do not explicitly address (e.g. tackle through further arguments) the question as to how a series of side-effects, which are partly certain, partly probable, and partly possible, are to be evaluated and weighted against each other."[323] The observation of Prantl (2011), that, "Current discussions of climate engineering still tend to be relatively abstract…"[324] seems to be better justified in the context side-effects. Although science could quantify the anticipated side-effects, there are still the unestimated, unanticipated side-effects. As Davies

[323]Betz and Casean 2012, p. 4.
[324] Prantl 2011, p. 1.

(2011) says, "…the heart of the resistance to geoengineering . . . is fear of the unknown."[325] Boyd (2008) calls it the "unknown unknowns."[326]

Incompatibility of the actual deployment scenario with the natural examples and field tests pose a serious challenge in the reliable assessment of the side-effects. Although volcanic eruptions provide an analogy for aerosol injection, such a natural example of the release of a single pulse of aerosol for a short duration is argued to be different from the artificial, long-term and irreversible exercises as in climate engineering.[327] "(N)either current climate models nor spatiotemporally confined tests can reliably foresee all side-effects of CE (climate engineering) employment."[328]

The issue of side-effects presents a confusing and paradoxical scenario as well. For instance, as MacCracken finds it, some of the adverse impact of climate engineering on Ozone and monsoon could be avoided if aerosol injection is directed to the Arctic. But in this case, countries that would benefit from an ice-free Arctic would be the losers.[329] Apart from the huge differences in side-effects between SRM and CDR, there is also the issue of the contextual and regional embeddedness of the side-effects. The assessment of the side-effects significantly varies depending on where it is deployed. For instance, "Surface albedo changes in urban settlements, … would pose far fewer risks to ecosystems than iron fertilisation of the oceans."[330] The clarity on side-effects is important for meaningfully invoking the other ethical principles of maximin rule, precautionary principle, justice, equity, and non-malfeasance in the climate engineering context.

The discussion on the side-effects spontaneously forces us into issues on the feasibility of climate engineering too. Feasibility considerations such as cost-benefit analysis, compensation, etc., require reliable forecast of the side-effects. The scepticism prevailing in the literature on the cost-benefit claims of the proponents is justified by the uncertainties over the side-effects. No cost-benefit and cost-effective analyses can be complete without incorporating the indirect costs like compensation, etc., in estimating which the unknown unknowns are serious hurdles. For Banerjee (2011), "A risk-based approach to geoengineering that internalizes any potential social costs might rule out geoengineering

[325] Davies, "Framing the Social, Political, and Environmental Risks and Benefits of Geoengineering: Balancing the Hard-to-imagine Against the Hard-to-measure." *Tulsa Law Review* 46 (2011): 261–282.
[326] P. W. Boyd, "Ranking Geo-engineering Schemes," *Nature Geoscience* 1 (2008): 722–724.
[327] See Crutzen 2006; Keith 2000a; Robock 2008; Seth, p. 8.
[328] Betz 2012, p. 480. See also Robock 2008; Robock et al. 2010
[329] MacCracken, in Banerjee 2011, p. 25.
[330] Bellamy, pp. 7-8.

altogether."[331] The serious flaws in cost-benefit analysis of the proponents as well as the opponents are a concern repeatedly figuring in the literature. "The incredible economics of geoengineering"[332] on the one hand does not seem to account for the "cost of dealing with unintended consequences or compensating injured parties"[333] on the other. It is such evasive approaches to the side-effects that create the hype that the "benefit-to-cost ratio of research and development of SRM technologies is "on the order of 1000 to 1."[334] These concerns about the side-effects in the present state of the debate need a serious revisitation by the climate engineering ethicists.

3.4.2.9 The Ambivalence about Moral Hazard

Moral Hazard is a prominent argument against climate engineering. As the results of this review shows, there are at least 32 papers dealing with this argument position. Unlike the case with side-effects, the proponents have confronted this argument on several counts and the moral hazard argument scenario is rich with arguments and counter arguments. Despite the pro and contra arguments on moral hazard, our review suggests that the weight of the moral hazard argument is still to be ascertained.

'Moral hazard' is a term drawn from insurance industry. In the insurance context, it is a fear that some kind of insurance may change the behaviour of the insured individuals increasing their exposure to risk. In the climate engineering context, it is the fear that the projected hope that there is a solution to climate change, may underestimate the attempts at mitigation by diverting the energy and resources meant to be used for it. Thus climate engineering may weaken the conventional efforts at combating climate change.[335] The Royal Society (2009) also set the tone of interdisciplinary research in this regard by advocating verification by social science studies about the existence of moral hazard.[336] Thilo Wiertz (2012)has found a philosophical point about moral hazard that it implies "an uncertainty about social reactions to the technologies and a (moral) value at stake."[337] A few empirical studies have given feedbacks contrary to the popular beliefs. The study by the German

[331]Banerjee 2011, p. 27.
[332] Barrett 2008, pp. 45-54.
[333] Banerjee 2011, p. 27. According to David Victor, "…the claim that geoengineering is remarkably cheap is based on simple assessments of silver-bullet geoengineering. In practice, however, the geoengineering cocktails that are likely to be deployed will not be cheap." David G. Victor "On the Regulation of Geoengineering," *Oxford Review of Economic Policy* 24 (2008): 322-327.
[334] See Bickel and Lane 2012, p. 3.
[335]See, Preston 2013, p. 25.
[336] Royal Society 2009, p. 29.
[337] Wiertz 2012, p. 49.

Federal Ministry of Education and Research concluded that "there is no empirical material within the climate engineering context to support the moral hazard thesis."[338] The tentative finding of a study on risk perceptions conducted by the Natural Environment Research Council in Great Britain was "contrary to the 'moral hazard' argument that climate engineering would undermine popular support for mitigation or adaptation."[339]

Amelung thinks that people's fear of climate engineering technology, "might even strengthen people's motivation to help reduce carbon emissions."[340] As such moral hazard cannot claim the psychological support for its arguments. Wiertz thinks that the moral hazard argument needs to be relocated within the contemporary climate sciences. He shows the limitations of pure empiricist perspective on moral hazard in climate engineering and advocates an approach with greater sensitivity to the political dimension, focusing on power relations in contemporary environmental discourses.[341] According to Hale (2012), moral hazard arguments "do not present an overriding *moral* reason for prohibiting climate engineering. …. moral hazard arguments are beset with problems of ambiguity and vagueness. As a consequence of this, … the moral hazard argument against geoengineering is underdetermined."[342]

Contrary to it, Lin (2012), also drawing on empirical studies, finds it "likely that geoengineering efforts will undermine mainstream strategies to combat climate change."[343] Resnik and Vallero (2011) think that moral hazard is a "speculative argument with little basis in fact," for researching and developing mitigation also are no zero-sum games.[344]Michaelson (1998) thinks that the moral hazard fears can be averted if climate engineering is pursued parallel to mitigation and if the "Proponents of geoengineering …take responsibility for ensuring that the policy does not degenerate into simple procrastination."[345]

In conclusion, it could be said, that though there is a serious concern with moral hazard in the literature as one of the leading argument against climate engineering, a comprehensive understanding of the debate at the moment does not present an imposing picture of moral hazard as a solid argument against climate engineering. Nor are the major

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[338] Wilfred Rickels, Gernot Klepper, Jonas Dovern, et al., Eds., *Gezielte Eingriffe in das Klima? Eine Bestandsaufnahme der Debatte zu Climate Engineering*, Sonderstudie für das Bundesministerium für Bildung und Forschung 111, Kiel Earth Institute 2011, p. 86. Tanslated by Thilo Wiertz, See Wiertz 2012, p. 50.
[339] Natural Environment Research Council (NERC) 2010. See, Wiertz, p. 50.
[340] Amelung 2012, p. 42.
[341] Wiertz 2012, pp. 52-55.
[342] Hale 2012, p.1.
[343] Lin 2012, p. 1.
[344] Resnik and Vallero 2011, p. 10.
[345] Michaelson 1998, p. 129.

assumptions of the moral hazard argument convincingly ruled out by the proponents of climate engineering. It seems the issue of moral hazard stands in need of greater empirical verification and more informed analysis. The concern with moral hazard is likely to weaken or strengthen depending on the positioning of climate engineering, as discussed above, as Plan A or Plan B for combating climate change. In nutshell, as with most other arguments on climate engineering, the strength of moral hazard argument also is still to be ascertained.

3.5 Conclusion

The debate about the ethics of climate engineering may be unprecedented in several respects, not only for its complexity, but for many other features as well. Despite its similarities with the GMO debate and the ethical debate that preceded the techniques of gene therapy, in some respects, it may be the first time in the history of the discipline of ethics that a technology that is in the offing, sparks off so much controversy and the very desirability of researching itself is subjected to such a critical scrutiny. Even before a major patent has been issued on research, the very mention of it sparks controversy in several circles. Besides, the review suggests extreme polarities in debate even at such an early stage from the hard-core 'Plan A proponents' through the 'neutral umpires' who prefers to wait and see to the deadly opponents who calls for a moratorium or ban on any type of research. "Geoengineering therefore stands out among emerging technologies for the way the ethical issues belong in a finite spectrum of temporal spaces stretching from the mere mention of it as a possible future technology through to the question of how to bring geoengineering activities to a close."[346]

Irrespective of such polarities, there are also a number of streams of consensus among the vast majority in the debate. The concerns over the dangers of climate change, the primacy of mitigation strategies over technical interventions, the growing discontent with the efficacy of the mitigation strategies, the point of extreme caution in employing the technology, the recourse to technology as a last resort, and the elements of unresolved uncertainty and risk are instances of such consensus in varying degrees.

This review of literature started with employing a standard methodology for identifying the relevant literature on the ethics of climate engineering. The methodology consisted of two rounds of searches termed as primary and secondary with the primary search words of climate engineering and its equivalent coinages along with the combination words of ethics and its derivates. The prominent arguments for and against climate engineering

[346] Preston 2013, p. 24.

picked up from the literature were aligned in a plain manner in the results section. The results section showed the enormous complexity of the debate. Six main frame arguments were identified with a number of subsets to each as defending the cause of climate engineering. Nine main frame arguments were identified with a number of subsets to each as opposing climate engineering ethically. It was also observed that the clashes between the arguments for and against climate engineering take place against the background of a number of significant uncertainties.

Further, in the discussion section, some observations were made on the general features of the debate landscape. The logistical observations highlighted the factors such as the complexity of the debate landscape, the semantic diversity and ethical ambiguity, the academic lopsidedness of the debate, missing contextual setting, etc. The thematic comments discussed and evaluated the claims of the lesser evil argument, the moral positioning of climate engineering, public engagement, governance concerns, the ambivalence about moral hazard, etc. Thus those argument structures outlined in the results, which were found to be underdeveloped in the debate and required further attention, were dwelt upon in the discussion section.

In the overall setting of this research, this chapter has provided us with the required platform for invoking our research question: *Can the development of climate engineering be just compatible with the Rawlsian principles of distributive, intergenerational and procedural justice?* Accordingly in the following three chapters we will be taking up this normative question. Many of the argument streams that we introduced in this chapter will be revisited in the following three normative chapters. Based on this background knowledge and our various assessment of it, in the next chapter we will look at the issue of distributive justice in climate engineering.

Chapter 4

Distributive Justice in Climate Engineering

4.1 Introduction

As we have already seen in the review of the literature in the previous chapter, justice constitutes one of the central pillars of the climate engineering controversy. The importance of justice in the debate is testified by the intense activity in this field as 37 papers represent this issue.[1] We have seen that ethical concerns pertaining to intergenerational equity, risk-transfer to future generations, beneficence and Belmont principle, participation of the vulnerable sections of the society, distributive and procedural justice and indigenous people and their involvement are the major issues related to justice in climate engineering. Advocates of climatic justice have vociferously raised concerns about the unequal distribution of cost and/or harms on the one hand and benefits on the other.[2] The difference principle, egalitarianism and human rights questions are also introduced in the debate in the context of justice.[3]The egalitarian fear is that climate engineering might widen the socio-economic inequalities already prevalent in the world.

The concerns with justice constitute the following three normative chapters of this study. Developing on the current debate on climate engineering and justice, we shall dwell in detail on three aspects of justice that we consider to be most challenging for the climate engineering controversy, namely, distributive justice, intergenerational justice and procedural justice. The issues of distributive, intergenerational and procedural justice are discussed respectively in the following three chapters. Although, the arguments in these chapters seem to go heavily against climate engineering, the approach of these normative chapters would not be to reject climate engineering altogether. Rather, it will be a call to the proponents of climate engineering to meet the conditions of justice before researching, developing and deploying climate engineering.

[1]See, Chapter 3, 3.3.2.5.
[2] Morrow et al. 2009; Bodansky1996; Keith 2000a, p. 276; Robock 2008a; ETC 2009, p.34; Mooney et al. 2012, p. 228; Tuana 2012; Bunzl 2007; Bunzl 2008.
[3]Betz and Casean 2012, p. 44; Pogge 2002.

In the present chapter, we shall focus exclusively on the challenges of distributive justice from climate engineering. Distributive justice, in general terms, deals with the distribution of goods in society and the norms on how harms and benefits ought to be shared among persons. Analysing the side effects of climate engineering in the light of distributive justice, we will see if climate engineering has the danger to increase benefits for some and harms for others. Is climate engineeringcompatible with distributive justice? What are the conditions of just research and application of climate engineering technologies from the perspective of the Rawlsian view of distributive justice? These are the lead questions that we will be tackling in this chapter.

In the first part of this chapter, we shall give a short sketch of the present status of the treatment of distributive justice in the literature. In the second part, we shall present the theories and principles of distributive justice developed by John Rawls. In the third part, we will focus on the question of under which conditions the research and application of climate engineering technologies would be just as seen from the perspective of the Rawlsian view of distributive justice. Accordingly, we shall make some practical recommendations in this regard in the final part of this chapter.

4.2 Current Research on Distributive Justice and Climate Engineering

It is difficult to do away with the temptation not to begin this discussion on a slightly negative note. In the entire spectrum of debate on the ethics of climate engineering, though there are several papers referring to the issues of justice along with other concerns, we could identify only a single paper[4] dealing exclusively with the issue of justice in climate engineering, let alone the issue of distributive justice. Svoboda et al. (2011) have discussed at length specifically on the justice concerns in SRM technologies.[5] Though justice is voiced as a major concern for ethics in climate engineering, no paper has tried to appropriate in detail the challenges related to distributive justice in climate engineering.

There are ten papers[6] highlighting one or other aspect of the distributive justice in climate engineering, though their precise concern is not with justice. We find them worth

[4] Svoboda et al. 2011.

[5] As we will see in the next chapter, the case of intergenerational justice is different as there is a comprehensive and exclusive analysis of the issues of intergenerational equity made by Burns. See Burns 2013.

[6] Preston 2013;Bunzl 2008;Ray 2010; Schneider 2011b; Svoboda et al. 2011; Morrow et al., 2009; Wylie Carr, Ashley Mercer, and Clare Palmer, "Public Concerns about the Ethics of Solar Radiation Management," in Christopher J. Preston, Ed., *Engineering the Climate* (Lanham: Lexington Books, 2014); Tuana et al. 2012; Jamieson 1996; Martin Bunzl, "Geoengineering Harms and Compensation," *Stanford Journal of Law, Science*

mentioning as they help advance the debate on distributive justice along some unique directions. The findings and recommendations of these papers are helpful for our study in examining the conditions that would enable the just research and deployment of climate engineering technologies as seen from the perspective of the Rawlsian view of distributive justice.

The unequal distribution of harms and benefits, compensation to the vulnerable populations, scientific uncertainties in the proper assessment of harms and benefits, and need for solidarity are the leading concerns from the point of view of distributive justice discussed in the current literature.

4.2.1 Harm-Benefit Asymmetry

A major concern in justice that is almost unanimously shared by various authors, and forcefully expressed by Preston (2013), is that "… the interests of the most powerful would be protected, while those less powerful will get secondary consideration (if they are considered at all)."[7]Preston's paper in 2013, titled, "Ethics and Geoengineering: Reviewing the Moral Issues Raised by Solar Radiation Management and Carbon Dioxide Removal," is one of the most articulate voices on the concerns with distributive justice in climate engineering. Preston (2013) holds that "Principles of beneficence and justice demand … the fair distribution of any benefits or harms that do occur."[8] Similarly, Aaron Ray (2012) and Schneider (2008) believe that the asymmetrical impact of climate engineering is causing serious challenges to distributive justice. Relying on Bunzl's prediction of the 10% of the World's population going worst off,[9] Ray (2012) raises one of the central questions in climate engineering as to who should bear the cost and benefits of climate engineering.[10]Schneider's (2011b) observation bears a lot of nuances in this context: "People in poor countries . . .

and Policy, Published online July 2011. Accessed online at https://drive.google.com/viewerng/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxtYnVuemx8Z3g6NDczZjdmYWE2N2YwNmEzOQ on December 2, 2014, accessed on June 3, 2016; S. Gardiner, "Why Geoengineering is not a 'Global Public Good,' and Why it is Ethically Misleading to Frame it as One," *Climatic Change* 121 (2013b): 513–525; Marion Hourdequin, "Geoengineering Solidarity and Moral Risk," Christopher Preston, ed., *Engineering the Climate – The Ethics of Solar Radiation Management* (Lanham: Lexington Books, 2014).

[7] Preston 2013, p. 30.

[8] Preston 2013, p. 28.

[9] Bunzl, "Geoengineering and Equity," Bunzl's Blog, comment posted May 12, 2008. Available at http://ccspp.blogspot.com/2008/05/geoengineering-and-equity.html, comment posted May 12, 2008. Accessed November 5, 2014.

[10] Ray 2010, p. 40.

have . . . (not) reaped much benefit from the activities that may be resulting in climate change."[11]

While Svoboda et al. (2011)[12] and Morrow et al. (2009)[13] relying on philosophical framework and scientific models respectively, have underscored the unequal distribution of harms and benefits as a big threat to distributive justice in climate engineering. Svoboda et al. (2011) rely mostly on the egalitarian theories of distributive justice advocated by John Rawls, Ronald Dworkin, Amartya Sen, and Richard Arneson along with the desert-based approach as the theoretical frame for assessing the desirability of sulphate aerosol injection. In the final analysis, despite the significant differences in the various models coined, it is found that "SAG is ethically problematic on all five of the major theories of distributive justice…."[14]Examining the problems associated with sulphate aerosol geoengineering (SAG), they conclude that it does not meet the requirements of distributive justice as it implies an uneven distribution of harm on persons and communities. The paper by Svoboda et al. (2011) seems to be the first systematic attempt to investigate the issues of justice in solar radiation management. Similarly, Morrow et al. (2009), analysing the impacts of SRM from the available simulation studies, have exposed a crucial irony in the potential benefits of SRM that even in our own generation, the beneficiaries of SRM will not be those who would bear the risks.[15]The assumption that the beneficiaries and the risk-bearers in SRM will be different is more or less confirmed by simulation studies. Most simulation studies cited elsewhere in this thesis show that the impact of SRM will be unevenly distributed.Conversely, those who would bear the risks will have very little benefit. Besides, the involvement of the private parties in climate engineering worsens the danger of the benefits being skewed away from those who would need it most.[16]

The concerns over the distribution of harm and benefit will have a significant role in forming the public opinion on climate engineering. Wylie Carr et al. (2014)[17] have observed that there is a strong intuitive concern expressed by the respondents of a study on the public opinion in climate engineering. The participants are curious to know how their respective regions would be affected. The effects of SRM as to who would benefit and who would stand

[11] Schneider 2011b, p. 329.
[12] Svoboda et al. 2011.
[13]Morrow et al. 2009.
[14] Svoboda et al., 2011, p. 18.
[15] Morrow et al. 2009, p.5.
[16] Preston 2013, p.30.
[17] Carr et al. 2014, p. 180.

to lose are serious concerns for the public.[18] Understandably, their approval of the scheme would be much subject to the harm or benefit to the region relative to them. It shows that concerns of distributive justice in climate engineering are intuitively inbuilt in the popular folk and would warrant the serious attention of the ethicists. Wylie et al. (2014) comment that though the issue is not adequately addressed by the formal bodies, the public is very saliently concerned about it. They also make the crucial observation based on public opinion, that, unlike the harmful effects of the climate change that are unintentional, harms caused by climate engineering would be ethically more aggressive as they are intentional in nature resulting from a invasive technique.[19]

4.2.2 Looming Scientific Ambiguities

Some papers highlight scientific and methodological concerns that pose challenges to clear discussions on distributive justice. There is ambiguity about the reliability of the climate engineering studies and predictions. Lack of definitive scientific data poses problems to defining the conditions for distributive justice. For instance, Tuana et al. (2012) have showed the inadequacy of the present earth system models in giving proper information on crucial geophysical factors in climate engineering like long time scales, differences in regional impacts, and the potential low-probability/high impact events, that are essential for assessing issues of distributive justice in climate engineering.[20] They propose that an appreciation of the issues of distributive justice would require a specific research agenda that would analyse comprehensively the social and physical impacts of SRM with a particular focus on their benefits and harms.[21]Ray (2010) also regrets over the lack of a proper mechanism for deciding on the global issues of distributive justice.[22]Jamieson (1996)[23] too thinks that no reliable prediction of the consequences of climate engineering is feasible due to the cascades of uncertainties.[24]

In a similar tone, Bunzl (2007), dwelling on the issue of harm, states that although there are concerns that it "[…] may seem obvious that at best then, the benefits of geoengineering will be unequal and at worst, some will benefit while some will be harmed."[25]

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[18] Carr et al. 2014, p. 185.
[19] Wylie et al. 2014, p. 180.
[20] Tuana et al. 2012, p. 142
[21] Tuana et al. 2012 p. 144
[22] Ray 2010, p. 40.
[23] Jamieson 1996.
[24] Jamieson 1996, pp. 327-328.
[25] Bunzl 2007. "Geoengineering and the problem of Comparative Judgements of Harm," from the abstract of the paper, available at http://adsabs.harvard.edu/abs/2007AGUFMGC52A..12B. Accessed May 3, 2015.

He opines that from an operational point of view, these are harder claims as there is no appropriate baseline for reaching at such conclusions and it is unclear as to whether those baselines would be commensurable.[26]

4.2.3 The Issue of Compensation

The question of compensating the harms is a concern over which many have pondered siginificantly. Preston, Bunzl and Gardiner have especially tried to pin point some of the subtle nuances of harm and compensation. Preston (2013) is also one of the leading ethicists to underscore the issue of compensation to the most affected in the likely scenario of the poor becoming poorer in the aftermath of climate engineering deployment.[27] Svoboda et al. (2011) also checked if SAG coupled with compensation would be justified. They warn that such a deal would significantly shoot up the cost of SAG.[28] Without ruling out sulphate aerosol injection, they invite the proponents of the same to "to recognize and address these ethical obstacles"[29] before advocating the implementation of sulphate aerosol injection.

Bunzl (2011) has focussed in some depth on the intrinsic complexities associated with harm and compensation.[30] The complexities of defining and deciding harm and compensations would invoke disputed baselines, differentiated causes of climate change, differing moral standing for harms relative to different nations, the problem of confirming the losers and gainers in the absence of clear norms and baselines, the nature of the harms that deserve recognition or compensation, and problems with welfarist conception of assessing harm and benefits. For instance, Bunzl (2011) draws on the example of the case of harm that may be caused to Canada and Uganda due to SRM. Canada may lose in agricultural yield due to reduction in global temperature and Uganda may lose due to the reduction in precipitation. These two harms are assessed to be of different moral standing. Drawing on the analogies of income and inheritance and luck egalitarianism, Bunzl (2011) argues for differentiated moral assessment of the harms resulting from SRM.[31] It may be concluded that "[…] it is unfair for

[26] Bunzl 2007.
[27] Preston 2013, pp. 30-31.
[28] Svoboda et al. 2011, p. 19.
[29] Svoboda et al 2011, p.1.
[30] Bunzl 2011.
[31] Bunzl 2011. Bunzl concludes that "Climate change will produce winners and losers. So, too, may mitigation of climate change. But the use of SRM as a mechanism of mitigation raises the possibility that there may be two kinds of losers: those already harmed by climate change who are made yet worse off by SRM, and those who gain from climate change and are made worse off by losing that gain. I have argued that even if both these losses are caused by the same action and are losses of the same degree, they should not be treated as equally deserving of compensation" (p. 76).

some to be worse off than others through no fault of their own among equally deserving people, it follows that it is also unfair for some to be better off than others though no more deserving. But in that case, those who are better off under such circumstances can have no complaint if they lose their better-off status."[32] But this norm is still problematic in the sense that it is "hard to limit its reach."[33]

Similarly, Gardiner (2013b)[34]has identified some dormant paradoxes in the seemingly sound ethical assumption of compensation.[35] Provision for compensation is no justification for causing harm. The conventionally ethical norm that the beneficiaries must compensate to the losers would exhibit its intrinsic irony in the context of climate engineering. For, this would presuppose that the benefits of climate engineering must be more than the costs irrespective of compensation. This might create a situation, which justifies the "infliction of all manner of costs onto some purely for the benefit of others, . . . without any discussion of matters such as rights, justice and responsibility."[36] Thus, according to Gardiner (2013b), it basically challenges the claim that climate engineering "benefits all."[37]

4.2.4 The Solidarity Approach

Marion Hourdequin (2014) advocates a rather pastoral approach suggesting the build up of solidarity through our relationship among ourselves, through social, and political institutions, and even through technological responses to climate change.[38] If we are motivated by the ideals of solidarity, there is a greater scope of reducing the harm and sharing the burden. He thinks that the solidarity approach can ensure greater distributive justice by considering the problem of abating climate change as a collective challenge. In Hourdequin (2014), there is the optimism that even in face of technological intervention against climate change, there can be distributive justice ensured in a collective response.[39]

Though the literature on the issues of distributive justice hitherto is relatively nominal, there seems to be a serious apprehension shared by the authors that from the justice point of view, even researching climate engineering could be like opening a Pandora's Box.

[32] Bunzl 2011, p. 73.
[33] Bunzl 2011, p. 74.
[34] Gardiner 2013a.
[35] Gardiner 2013a.
[36] Gardiner 2013a, p. 519.
[37] Gardiner 2013a, p. 519.
[38] Marion Hourdequin, "Geoengineering, Solidarity and Moral Risk," in Christopher Preston, Ed., *Engineering the Climate – The Ethics of Solar Radiation Management* (Lanham: Lexington Books, 2014), pp. 15-32.
[39] Hourdequin 2014, p. 32.

There seems to be unequivocal consensus among those who address the issue of distributive justice in climate engineering that there is a pressing need for expanding the ethicalresearch, as the work done so far is quite insufficient and does not absorb the seriousness and complexity of the issue.[40] Unsurprisingly, almost all the pieces of literature reviewed herein find only challenges to distributive justice from whichever form of climate engineering, mostly stratospheric aerosol injection, and to our reading, there is no major mention in the literature where climate engineering presents itself as providing positive opportunities for global distributive justice.

The literature also shares the tacit assumption that the harms and benefits of climate engineering will be significantly disproportionate among regions and peoples. Although some authors raise the issue of compensation, no context-specific case studies have been done about it. Besides, the debate on distributive justice is extremely polarised towards the analysis of SRM technologies with practically little attention paid to the distribution of the harms or benefits of CDR approaches.

Yet a major missing link is between the concerns of distributive justice in climate change in general and the ramifications of this change for distributive justice in climate engineering in particular. Though there are a number of scholarly publications dealing with the issues of distributive justice in relation to the challenges of anthropogenic climate change,[41] those studies fall short of a due incorporation of the challenges to the same from climate engineering. For instance, the paper by Jochen Prantl (2011),[42] highlighting a series of challenges to distributive justice from climate changes, actually dwells very little on climate engineeringand its title seems to be deceptively misleading. It still remains an open task for the climate engineering ethicists to build upon the platform provided by Robock et al. Preston's reasonable fear that "The many injustices of climate change foisted on the global poor could be unintentionally compounded by geoengineering,"[43] also needs to be substantiated by more imposing scientific evidences.

4.3 The Rawlsian Principles of Justice as a Theoretical Frame for Distributive Justice in Climate Engineering

[40] See for instance, Wylie et al., p. 181.
[41] H. Shue, "The Unavoidability of Justice," in A. Hurrell, B. Kingsbury, Eds., *The International Politics of the Environment* (Oxford, UK: Oxford University Press, 1992): 373–397.
[42]Prantl 2011.
[43] Preston 2013, p. 28.

As a political philosopher Rawls explored the ways to settle the prevalent tension within democratic society between liberty and equality. Rawls assumed that the diversity of worldviews in the society resulting from the social order can support greater freedom for all citizens.[44] His first major workwas *Theory of Justice* first published in 1971, which deals particularly with the problems of distributive justice. His theory known as *Justice as Fairness* is further refined and expanded in his subsequent works, *Justice as Fairness – A Restatement* (2001), *Political Liberalism* (1993), and *Law of Peoples* (1999).

4.3.1 Justice as Fairness

The norms of distributive justice developed by John Rawls in his *A Theory of Justice* in 1971 and the norms of international distributive justice developed in his *The Law of Peoples* in 1999 provide a tangible theoretical frame to evaluate under which conditions the research and application of climate engineering technologies would be just. Since an exhaustive presentation of Rawls' ideas of justice is beyond the scope of this study, we will be dwelling only on those aspects relevant for the discussion of distributive justice in climate engineering, true to the concern of this chapter. The perspectives of John Rawls on intergenerational justice and procedural justice will be discussed later as warranted by the concerns of the subsequent two chapters.

Rawls is an egalitarian philosopher of the social contract tradition. Relying on generalised and abstract variants of the social contract theory, Rawls reaches at his theory of Justice as Fairness in his *Theory of Justice.* Rawls' theory has two major derivative principles of justice, namely, the *liberty principle* and the *difference principle*. Reconciling the principles of liberty and equality, Rawls's objective in *Theory of Justice* is to provide "a reasonably systematic alternative to utilitarianism."[45] According to Rawls, there were two objectives to developing the conceptions of justice as fairness: "A convincing account of basic rights and liberties, and of their priority, was the first objective of justice as fairness. A second objective was to integrate that account with an understanding of democratic equality, which led to the principle of fair equality of opportunity and the difference principle."[46]

Rawls describes justice as fairness in the following terms: "They are the principles that free and rational persons concerned to further their own interests would accept in an initial position of equality as defining the fundamental terms of their association. These

[44]https://plato.stanford.edu/entries/rawls/
[45] Rawls, *Theory of Justice*, p. xi.
[46] Rawls, *Theory of Justice*, p. xii.

principles are to regulate all further agreements; they specify the kinds of social cooperation that can be entered into and the forms of government that can be established. This way of regarding the principles of justice I shall call justice as fairness."[47] As for his starting point, Rawls looks for a common point of view of justice, a set of principles that would be agreed upon by all parties, unlike the disputed norms of the just and the unjust in existing societies. If such principles are found, those will be the norms followed by major institutions[48] in the distribution of fundamental rights and duties, and in deciding on fair divisions of benefits resulting from social cooperation.

4.3.2 The Original Position

Rawls envisages a hypothetical state of affairs where these principles can be derived from. This is technically termed as 'original position' in Rawls' theory. Principles of justice are the principles chosen by 'rational persons' in an 'original position' under a 'veil of ignorance.' Here rational persons are those self-interested individuals who are guided by a mutually disinterested rationality. Rawls describes the mutually disinterested rationality as follows: "the persons in the original position try to acknowledge principles which advance their system of ends as far as possible. . . . The parties do not seek to confer benefits or to impose injuries on one another; they are not moved by affection or rancor. Nor do they try to gain relative to each other; they are not envious or vain."[49]

An ideal state of justice is explained by Rawls with the help of the hypothetical device, the 'original position' where rational parties make a relevant agreement on moral principles. The term 'original position' refers to an imagined state of mind wherein individuals choose principles of justice behind a veil of ignorance. The expression "veil of ignorance" means that no one knows his/her social position or his/her place in the society in deciding on the principles of the distribution of primary social goods. Although the contracting parties do not infringe on one another's interests, they are governed by certain interests and responsibilities so that they may protect their liberties.[50] The particular form that these interests would take is not known by the parties in the original position. The power of

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[47] Rawls, *Theory of Justice*, p. 10.
[48] The major social institutions are the political constitutions, and principal economic and social arrangements. Consequently, the legal protection of freedom of thought and liberty of conscience, competitive markets, private property in the means of production, and the monogamous family are examples of major social institutions (*Theory of Justice*, p. 6).
[49] Rawls, *Theory of Justice*, p. 125.
[50] Rawls, "Distributive Justice: Some Addenda," in Samuel Freeman, ed., *Collected Papers: John Rawls*. (Massachusetts: Harvard University Press, 1999):154-175, p. 155.

the mutual agreement in the original position is guaranteed as the original position embodies those conditions widely recognised as fair in choosing and justifying principles of justice. The fact that a particular moral principle or theory would be accepted and preferred in such conditions against plausible alternatives is a credible argument for supporting the chosen moral theory.[51]

The notion of the original position is conceived by Rawls to ensure the choice of principles of justice in a fair manner. The principles of justice are moral principles to be chosen in an impartial position. There should be nothing that would favour the subjective positions of the parties. The contracting parties, as they are ignorant of their subjective characteristics under the veil of ignorance, are freed from the binding conditions that would enable them to insist on principles favouring themselves. Thus for Rawls, the veil of ignorance not only brings about unanimity on principles of justice in the original position, but is also necessary to the condition of taking up the moral point of view.[52]

The original position of equality involves the circumstances in which all persons would agree on a just system of distribution. This imaginary situation assumes the equality of the competent members of society with respect to primary goods. Further, the individual is unaware of his/her own position in society, talents and abilities, conditions of life in society, potential opportunities, goals, chances of success, etc. Under this ignorance, one is to choose the principles of conduct that would be best for oneself, with a view to maximize the possession of primary goods.[53] In this maximisation attempt too, each person is assumed to calculate rationally.[54] This is because he/she is unaware of his/her share of resources. Therefore, the possible arrangement to which one is to give consent is one in which all shares are equal.

4.3.3 The Two Principles of Justice

Given this state of affairs, what are the principles that all parties can unanimously agree upon? Given his position that justice pertains to the basic structure of the society, Rawls does not go for an elaborative list of principles that could deal with particular social concerns of our social life. Rather, he draws two central principles pertaining to the basic structure of the society. There are two major principles of justice that would be agreed upon

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[51] Dan W. Brock, "The Theory of Justice," *The University of Chicago Law Review*, 40:3 (1973): 486-499.
[52] Brock 1973, p. 489.
[53] Rawls, *Theory of Justice,* pp. 15-19.
[54] Steven M. DeLue, "Aristotle, Kant and Rawls on Moral Motivation in a Just Society," *The American Political Science Review* 74:2 (1980), p. 385.

by persons in the original position. The initial formulation of the two principles are as follows: "First: each person is to have an equal right to the most extensive scheme of equal basic liberties compatible with a similar scheme of liberties for others. Second: social and economic inequalities are to be arranged so that they are both (a) reasonably expected to be to everyone's advantage, and (b) attached to positions and offices open to all."[55]Among these two, the first principle has a distinct priority over the second.[56] The share of basic liberties for each person should be compatible with the share of basic liberties of every other person having the same share of basic liberties.

One of the key features of justice as fairness is that it guarantees a secure protection to the equal liberties.[57] As Rawls understands, any liberty will consist of three components: firstly, the agents who are free, secondly, the restrictions or limitations that they are free from, and finally, what is that they are free to do or not to do.[58] Liberty is unequal when one group enjoys a greater liberty than another, or its liberty is not as much as what it should be. Such a basic liberty is restricted only for the sake of liberty itself.[59] Justice as fairness provides a strong case for individual liberty as well. According to Rawls, "whenever a society sets out to maximize the sum of intrinsic value … it is liable to find that the denial of liberty for some is justified in the name of this single end. The liberties of equal citizenship are insecure when founded upon teleological principles."[60]

Rawls argues that the utilitarian conflation of individuals for the sake of maximum happiness or maximum utility will cause serious injustice meted out to humans. An individual could reap greater benefits in future by sacrificing a certain comfort. It may be just as the concerned individual itself is paying the cost and reaping the benefit. However, it would be different if another person is inflicted suffering by which *others* may reap benefit. This would be an unfair deal. It is tantamount to injustice if some beneficiaries are created by forcing other persons to be benefactors. Similarly, institutions also can be channels of injustice if they produce social benefits and distribute these inequitably or in some fashion that would violate the rights of some individuals.[61]

4.3.4 Primary Goods - A Metric of Individual Benefits and Social Cooperation

[55] Rawls, *Theory of Justice*, p. 53.
[56] Rawls, *Theory of Justice*, pp. 53-54.
[57]Rawls, *Theory of Justice,* p. 180.
[58]Rawls, *Theory of Justice,* p. 177.
[59]Rawls, *Theory of Justice,* p. 178.
[60]Rawls, *Theory of Justice,* p. 185.
[61]Rawls, *Theory of Justice,* pp. 242 ff

For Rawls, 'primary social goods' are the appropriate metric against which individual benefits in social cooperation is to be evaluated. Rawls defines primary goods as 'all-purpose means' that a rational person would require pursuing his/her conception of the good.[62] They comprise social background conditions and all-purpose means necessary to form and rationally pursue the good. Primary goods are partial conceptions of the good agreed by the citizens in order to make interpersonal comparisons that are necessary for establishing the principles of justice.

Rawls classifies primary goods into natural and social primary goods. Examples of natural primary goods would be health and vigour, intelligence and imaginations. Natural primary goods are not under the control of social institutions although their achievement and expressions can be conditioned by social institutions. Rawls recognises that differences in natural primary goods also are to be addressed by social justice.[63]

Examples of primary social goods listed by Rawls are the following:

(i) Basic rights and liberties

(ii) Freedom of movement and free choice of occupation against a background of diverse opportunities

(iii) Powers of prerogative of offices and positions of responsibility in the political and economic institutions of the basic structure

(iv) Income and wealth

(v) Social bases of self-respect.[64]

The principles of justice should ensure that all citizens have access to these primary social goods and that these goods are protected. The principles of justice should also provide each individual with a fair share of these all-purpose means. According to Rawls, when an index of primary goods is incorporated into the two principles of justice, the principles along with the index permits the characterization of what are citizens' appropriate claims to social resources.[65]

Rawls has underlined the importance of the primary social goods to enable citizens to develop and exercise the following two moral powers: (a) the capacity for a sense of justice,

[62]Rawls, *Theory of Justice*, pp. 79-81.
[63]Rawls, *Theory of Justice*, p. 54.
[64] The social bases of self-respect are elucidated in institutional terms supplemented by features of the public political culture such as the public recognition and acceptance of the principles of justice. See, John Rawls, "The Priority of Rights and Ideas of the Good," in Samuel Freeman, ed., *Collected Papers: John Rawls* (Massachusetts: Harvard University Press, 1999), pp. 454-455.
[65] John Rawls, "Social Unity and Primary Goods," in Samuel Freeman, ed., *Collected Papers: John Rawls*. (Massachusetts: Harvard University Press, 1999), p. 370.

the capacity to understand, to apply and to act from the principles of political justice that specify the fair terms of social cooperation; and (b) the capacity for a conception of the good, i.e. the capacity to have, to revise and to pursue rationally a conception of the good.[66] It also enables them to pursue their determinate conceptions of good.[67] Rawls states, "primary goods are now characterized as what persons need in their status as free and equal citizens, and as normal and fully cooperating members of society over a complete life."[68]

4.3.5 Principle of Efficiency

Rawls takes recourse to the principle of efficiency in relation to distribution in economics. Every policy is to be evaluated in terms of the possible worst scenario resulting from that particular theory. According to the principle of efficiency, a system cannot be efficient if there is an alternative arrangement that could improve the situation of some people without rendering the situation of any of the other people worse.[69] Rawls distinguishes two views on social justice, namely, the 'general' and the 'special.' In the general view, which is more basic, "[a]ll social values - liberty and opportunity, income and wealth, and the social bases of self-respect - are to be distributed equally unless an unequal distribution of any, or all, of these values is to everyone's advantage."[70] This view holds in instances of low social wealth when establishing basic liberties is impossible and cannot be effectively exercised for all. The special view "removes the indeterminateness of the principle of efficiency by singling out a particular position from which the social and economic inequalities of the basic structure are to be judged."[71]

4.3.6 Difference Principle

The issue of arranging the inequalities is addressed by the second principle, known as the difference principle. The interests of the least advantaged in the society are safeguarded in

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[66] See, John Rawls, *Justice as Fairness: A Restatement,*Erin Kelly Ed. (Cambridge/Massachusetts: The Belknap Press of Harvard University Press, 2001), pp. 18-19.

[67] Rawls, *Justice as Fairness: A Restatement*, pp. 57-58. Rawls coins the terms both the good and the goods in a dual sense. The term good refers to his theory of good which he calls, "goodness as rationality." (Rawls, *Theory of Justice*, p. 347ff). Goods refer to his notion of primary goods both natural and social. The theory of the good was originally presented to reinforce Rawls's claims about the nature and role of primary goods. See, Christine M. Korsgaard, The Unity of the Right and the Good in John Rawls's Thought. Available at http://www.people.fas.harvard.edu/~korsgaar/CMK.Rawls.Right.Good.pdf. Accessed on September 2, 2017.

[68] John Rawls, "Preface for the French Edition of a Theory of Justice," in Samuel Freeman, Ed., *Collected Papers: John Rawls* (Massachusetts: Harvard University Press, 1999), p. 417.

[69] Rawls, *Theory of Justice*, p. 159. See also, http://www.ohio.edu/people/piccard/entropy/rawls.html. Accessed October 11, 2014.

[70]Rawls, *Theory of Justice,* p. 54.

[71]Rawls, *Theory of Justice,* p. 65.

the difference principle with an added norm for the distribution of the primary goods.Rawls advances the difference principle in order to address the issue of social and economic inequalities in the society within the framework of the principle of equal liberty. The difference principle is more concerned with institutions or practices in general than with particular actions or persons. The only circumstance under which social inequalities would be justified is when they turn out to be beneficial to the least well off. Justice is done to someone who is least advantaged, only if one is rendered better from a state he/she would be in without the inequality. According to the difference principle the benefits to the least advantaged group must be maximized,[72] for, "social and economic inequalities should be evaluated in terms of how well off they leave the worst off."[73] The only acceptable deviations from equality in this situation are those that would bring maximum benefit to the least privileged members of society.[74] For example, if a high salary to some individual is to induce the build up of the economy leading to the better quality of life for all, then this inequality is not unjust and would be acceptable.

Precisely, who are the least advantaged? For Rawls, they are those whose family and class origins are more disadvantaged than those of others, whose natural endowments permit them to fare less well, and whose fortune and luck in a course of life turn out to be less happy.[75] The least advantaged are born into and would remain in such groups throughout their life.[76] As primary social goods and resources in terms of income and wealth are used in defining the worst off, it is clear that they are the poorest in the society.

There are three variants of the difference principle in *Theory of Justice*. In the first version, the principle suggests that economic and social inequalities must be "to everyone's advantage."[77] In the second variant, there is greater light shed on the "everyone." "Assuming the framework of institutions required by equal liberty and fair equality of opportunity, the higher expectations of those better situated are just if and only if they work as part of a scheme which improves the expectations of the least advantaged members of society. The intuitive idea is that the social order is not to establish and secure the more attractive prospects of those better off unless doing so is to the advantage of those less fortunate."[78] In

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[72] J. E. J. Altham, "Rawls's Difference Principle," *Philosophy* 48 (1973), p. 75.
[73] Philippe Van Parijs, "Difference Principles," in Samuel Freeman, ed., *The Cambridge Companion to Rawls* (Cambridge/ New York: Cambridge University Press, 2003), p. 200.
[74] L. Richard Della Fave, "On the Structure of Egalitarianism," *Social Problems* 22 (1974): 200-205.
[75]Rawls, *Theory of Justice,* p. 83.
[76] Rawls, "Social Unity and Primary Goods," p. 364.
[77]Rawls, *Theory of Justice,* p. 53.
[78]Rawls, *Theory of Justice,* p. 65.

this formulation, society consists of only the 'more fortunate' and the 'less fortunate,' in terms of the social and economic advantages they possess. In the third formulation, "social and economic inequalities are to be arranged so that they are both (a) to the greatest benefit of the least advantaged and (b) attached to offices and positions open to all under conditions of equality of opportunity."[79]Van Parijs comments that the third formulation achieves the maturation from the requirement of 'some improvement' to a 'maximal improvement' of the least advantaged.[80] The difference principle, by defining the fair expectations of the members, is geared towards providing adequate resources for realizing everyone's capacities for free and responsible agency.[81]

In his *Theory of Justice: A Restatement*, Rawls has imposed certain constraints upon the application of the difference principle. For instance, the concept of 'the most extensive equal liberties for all' has priority over the difference principle.[82] Even if forced labour may be somehow considered to be improving the position of the least-advantaged in the society in the long-run, it cannot be justified. Indeed, because it conflicts with the first principle, which states each person is to have an equal right to the most extensive scheme of equal basic liberties compatible with a similar scheme of liberties for others.

The two principles of justice are supposed to regulate the social and economic inequalities in the basic structure of the society. Governed by the principles of justice, these inequalities are meant to evolve over time to the greatest benefit of the least advantaged in the society. Thus there is a rational agreement shared by these principles. Since these principles follow equitable division of primary goods as the benchmark of comparison, they also facilitate equality.[83] The social circumstances of the individuals are compared and evaluated against the social primary goods. However, Rawls is keen to add that the index of primary social goods is not a measure of individual's overall satisfaction or dissatisfaction, though it serves as a ground for interpersonal comparisons for the purpose of justice.[84] The distribution of primary goods according to the principles of justice is the standard for the basic structure of the society to be just.

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[79]Rawls, *Theory of Justice,* p. 72.
[80] Van Parijs "Difference Principles," in *The Cambridge Companion to Rawls,* pp. 201-203.
[81] Samuel Freeman (ed.), "Introduction," in *The Cambridge Companion to Rawls,* pp. 7-8.
[82] John Rawls, *Justice as Fairness: A Restatement*, p. 97.
[83] Rawls, "Social Unity and Primary Goods," in *Collected Papers: John Rawls,* p. 374.
[84] John Rawls, "A Kantian Conception of Equality," in Samuel Freeman, ed., *Collected Papers: John Rawls* (Massachusetts: Harvard University Press, 1999), p. 261.

Given the conditions of choice in the original position, the principles chosen will be fair to everybody. This is the basis of justice as fairness in Rawls' theory. Such an understanding of justice as fairness, would deliver fundamental rights and duties, benefits and burdens, within a society, striking a proper balance between competing claims to the advantages of social life. This public conception of justice will be the standard for a well-ordered society.[85]

4.3.7 International Distributive Justice

In his *The Law of Peoples*, Rawls reflects extensively on international justice. Here Rawls describes principles that should govern the foreign policy of a liberal people.[86] It could be noticed at the outset that - as Michael Blake and Patrick TaylorSmith have observed - in the *Law of Peoples*, "Rawls' perspective is unabashedly *international* rather than *global*. Unlike the early left institutionalists who conceive of the world as a single cooperative unit and seek a single principle of distributive justice to govern everyone, Rawls explicitly seeks principles that will regulate the interactions among territorially defined political, corporate agents that have a monopoly on the legitimate use of force, called *peoples*—and, only indirectly, govern individuals."[87]

Rawls' concept of international distributive justice centres on the notion of 'well orderliness.' It requires a 'realistic utopia.'[88] Rawls assumes that an international system composed of well-ordered peoples with representative governments will be peaceful.[89] Rawls thinks that a world state would be impractical due to the cultural and communication obstacles.[90]From the provisional list of principles to be followed by the peoples[91] as given by Rawls, we could identify the following principles that are relevant for climate engineering discussions.

1. Peoples are free and independent, and their freedom and independence are to be respected by other peoples.
2. Peoples are to observe a duty of non-intervention.

[85] Brock, "The Theory of Justice," p. 488.
[86] Rawls, *The Law of Peoples*, pp. 9–10.
[87] Blake and Smith 2013
[88]Rawls, *The Law of Peoples*, pp. 11–12.
[89]Rawls, *The Laws of Peoples*, pp. 44–54; See also Blake and Smith 2013.
[90]Rawls, *The Law of Peoples*, p. 36.
[91]Rawlsian peoples are said to be not well defined. Most commentators seem to interpret it as synonymous with citizens of democratic nation states. Blake and Smith define peoples as "territorially defined political, corporate agents that have a monopoly on the legitimate use of force." (Blake and Smith 2013).

3. Peoples are to honour human rights.
4. Peoples have a duty to assist other peoples living under unfavourable conditions that prevent their having a just or decent political and social regime.[92]

Michael Blake and Patrick TaylorSmith make the critical observation that a version of the difference principle or anything of the sort is absent in this list. "[…] unlike individuals in the first original position, the peoples represented in this second, international original position will not demand that inequalities among them be justified by improving the lives of the least well-off person or people."[93]

Michael Blake and Patrick TaylorSmith identify the following distributive elements in the *Law of Peoples.* "If a deep material inequality among peoples undermined their ability to, say, be considered equals in the negotiation of treaties or tempted peoples to inappropriately intervene in the domestic affairs of other peoples, then that would be a reason—from the standpoint of international justice—for eliminating that inequality."[94] For Rawls, when every citizen in a well-ordered nation is able to lead a well-ordered life and assured of protection against starvation and poverty, the fact of some being wealthier than other is not tantamount to injustice.

4.4 Climate Engineering and Distributive Justice from the Rawlsian Perspective[95]

[92]Rawls, *The Law of Peoples*, p. 37.
[93] Blake and Smith 2013.
[94] Blake and Smith 2013.
[95]It is to be noted that Rawls has been criticised by many scholars from several angles. Susan Moller Okin has criticised Rawls for the weakness of his theory as sustaining the hierarchies and injustices in the familial setting (Susan Moller Okin, *Justice, Gender, and the Family* (New York: Basic Books, 1989).Harsanyi argues that Rawlsian original position will not lead to his two central principles of ethics (Harsanyi, "Can the Maximin Principle Serve as a Basis for Morality? A Critique of John Rawls' Theory, *American Political Science Review* 69, 2 (June 1975):594–606). Amartya Sen objects to Rawls' notion of primary social goods. Sen holds that what matters is not just the distribution of primary goods but the efficiency with which people use those goods to pursue their goals (Amartya Sen, *Inequality Reexamined* (Oxford University Press, 1992). Gerald Cohen's targets of criticism are Rawlsian difference principle, the application of the difference principle only to social institutions, and primary goods as the standard of equality. Feminists also take Rawls to task for ignoring the social system based on patriarchy and the gender divisions in labour and household. John Harsanyi criticises Rawls maximin reasoning.Matsuda's objection to Rawls is that Rawls fails because of his central choice of abstraction as a method for moral philosophising (Mari J. Matsuda, "Liberal Jurisprudence and Abstracted Visions of Human Nature: A Feminist Critique of Rawls' Theory of Justice," N.M.L. Rev. 16: 613 (1986)). Some other major critiques of Rawls are Onora O'Neill, "Political Liberalism and Public Reason: A Critical Notice of John Rawls, Political Liberalism." *The Philosophical Review* 106: 3 (1997): 411-428; Brian Bary, The

As we can easily see, there is no reference to climate engineering in Rawls, especially as climate engineering is a recent development. However, our review of literature has shown that Rawls has been referred to by a number of ethicists on climate engineering. Our choice of Rawls for dealing with the issues of distributive justice was already justified in the introductory chapter. In this section, we shall be appropriating the concerns with distributive justice in climate engineering within the theoretical frame of distributive justice developed by Rawls. We shall apply various principles of distributive justice advocated by Rawls to the various challenges emerging from the potential scenario of research and development and deployment of climate engineering. The prominent elements of distributive justice in Rawls relevant for climate engineering are the following:

1. Justice as fairness where Rawls underscores principles of basic liberty and freedom and the equality of opportunity. The various principles of distributive Justice developed in his *The Law of Peoples* where he dealt with international distributive justice can also be coined alongside.
2. The Principle of Efficiency.
3. The Difference principle.

As we have seen, the postulation of an original position of equality and the adherence to this position as providing the norms of social interaction is the starting point of the Rawlsian theory of justice as fairness. The detachment from the subjective positions of the parties for making fair choices, impartial positioning of the rational parties, unanimity of moral principles, protection of one's own rights and liberties without infringing on others' rights, and the original position of equality with a mutual consensus on a just system of distribution are the major emphases in justice as fairness. Anticipating the findings for this study, we are inclined to agree with the other authors who hold that Rawls's principles of justice cannot endorse climate engineering proposals in the present manner for the vast challenges to distributive justice that they offer. However, it could also be noted that an in-depth

Liberal Theory of Justice: A Critical Examination of the Principal Doctrines in a Theory of Justice by John Rawls. (1975): 598-603; Brian Barry, "Liberalism and Want-satisfaction: A Critique of John Rawls." *Political Theory* 1:2 (1973): 134-153.

Among the various criticisms levelled against Rawls, we are inclined to think that perhaps what is most relevant in the context of applying Rawls to climate engineering is Matsuda's denouncement of the Rawlsian method of abstraction. As we will be seeing in the subsequent discussions, there are logically and rationally idealistic situations arising from Rawls which if employed would not have caused the anthropogenic climate change and the very need for either mitigation or climate engineering. Thus in the intersection between Rawls and climate engineering justice, there are occasions where one will find the Rawlsian system more as a logical game than a realistic engagement of the existing practical issues. This will be particularly clear in Chapter 7 where the Rawlsian vision of pure procedural justice appears to be somewhat tautological.

appropriation of Rawls can open up new opportunities to the debate on climate engineering as the awareness of the challenges suggests new directions and measures for advancing the debate in its future course.

4.4.1 Challenges to Equality and Liberty

The research and development phase as well as the post-deployment scenario of climate engineering are loaded with serious challenges to the principles of distributive justice advocated by Rawls. In fact, appropriating the Rawlsian moral principles in the context of distributive justice in climate engineering cannot start with the ideal original position that Rawls envisaged for the just distribution of primary goods. For, the very context of climate change, which warranted the discussion on climate engineering, presents itself as an unequal situation with huge disparities at the natural, social and geographical levels. As many authors have noticed, the climate change scenario brings forth the greatest havoc on the lives of the global poor because of mere "geographical bad luck."[96] There is almost a consensus among ethicists that the poor populations of the world are susceptible to the challenges of climate change. For example, a rise in sea level by one meter would submerge 18% of the land inhabited by 11% of the population.[97] One third of the African people live in drought prone areas. As per the IPCC 2007 report, a significant impact of the climate change is the large-scale loss of agricultural land in Africa. There are also the fears of the projected rise in several diseases due to the rise in temperatures in several parts of Africa. The IPCC 2007 report also predicts water shortage and land degradation leading to severe poverty throughout Asia due to shrinking glaciers.[98]

The primary condition for determining the choice of principles by rational people is that they be ignorant of their particular status in the society as individuals. The already differentiated responsibilities for climate change and the consequent inequalities already prevalent in the climate change scenario does not provide the ideal state of an original position with equal opportunities and equal rights that would enable people to make fair choices by following the moral norms as envisaged by Rawls. The initial position of equality that is to define the terms of association among the various parties is already absent in the context of climate engineering. Overcoming the self-interest of the parties through their

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[96] Preston 2014, p. 80.

[97] S. Agrawala et al., "Development and Climate Change in Bangladesh: Focus on Costal Flooding and the Sundarbans," 2003. Available at http://www.pisa.oecd.org/dataoecd/45/55/20155658.pdf. Accessed April 9, 2016.

[98] IPCC, S. Solomon et al. Eds., *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel of Climate Change* (Cambridge, UK and New York, USA: Cambridge University Press, 2007).

inability to choose principles that unfairly suit them may not be relevant in the context of present state of affairs with climate change and conversely to climate engineering.

While the pre-deployment context itself is a matter of concern, the research and development and deployment of climate engineering is poised to go against the equal right to the most extensive scheme of equal basic liberties compatible with a similar scheme of liberties for others, as envisaged by Rawls. Although there are several elements of uncertainty in regard to the impact of climate engineering, the simulation studies show that the impact of climate engineering, especially SRM, will be unevenly distributed. The prevalent uncertainties in the assessment of risk and harm associated with SRM are also swinging more towards worsening the regional imbalance in regard to the risks of SRM. The data from various simulation studies show that SRM and distributive justice are very much incompatible. Relying mainly on the four major simulation tests in SRM by Matthews and Caldeira,[99] Robock et al.,[100] Trenberth and Dai,[101] and Brewer,[102] we shall show that climate engineeringwould violate the fundamental principles of the Rawlsian view of distributive justice.

Matthews and Caldeira studied the future scenarios of transient climate simulations in which CO_2 emissions continue unabated and climate engineering is used to stabilize the temperatures. In their method they took the globally averaged absorbed solar radiation as equal to the radiative forcing from anthropogenic CO_2.[103] In the simulation there were interesting results showing differentiated spatial changes in precipitation. In the simulation model of climate change without climate engineering, there was only a slight decrease in globally averaged precipitation by 0.02 mm/day from 1900 to 2100. However, in the model with climate engineering, the atmosphere did not warm sufficiently at 2100 relative to 1900. Here, the global averaged precipitation decreased by 0.18 mm/day from 1900 to 2100. Most surprisingly, the regional differences went up to 1.0 mm/day over tropical land areas.[104] Regions like Africa, South America, and South-Eastern Asia are predicted to be hit most severely by the reduction in the precipitation.

[99]Matthews and Caldeira 2007.
[100] Robock 2008b, pp. 14-18.
[101] Kevin E. Trenberth, and Aiguo Dai, "Effects of Mount Pinatubo Volcanic Eruption on the Hydrological Cycle as an Analogue of Geoengineering," *Geophysical Research Letters* 34 (2007), no. 15.
[102]Peter G. Brewer, "Evaluating a Technological Fix for Climate," *Proceedings of the National Academy of Sciences* 104 (2007): 9915-9916.
[103] Matthews and Caldeira 2007, p. 9950.
[104] Matthews and Caldeira 2007, pp. 9950-9951.

It is feared that the presence of radiative forcing agents in the atmosphere would produce complex patterns of changes in warming, precipitation, and patterns of climate like El Niño and monsoons, which vary from region to region. The impact of sulphate aerosol in balancing the global mean radiative forcing upon local climate patterns leading to substantial changes has been predicted by Lunt et al.[105] Bala et al. have shown that although global mean surface air temperature may be restored, it does not restore the global mean precipitation.[106]

As we have seen already, many proponents of the SRM models of climate engineering have used the Mount Pinatubo effect in 1991 as a justifying reference to climate engineering. However, many scientists were eager to show the side effects of the Pinatubo eruption, which are often overlooked. For assessing the issue of distributive justice in SRM, learning the lessons from the dark sides of the Pinatubo effect is crucial. Scientists at the National Centre for Atmospheric Research showed the huge impacts caused by the eruption leading to reduced precipitation, soil moisture, and river flow in many regions.[107] The study by Trenberth and Dai in 2007 shows that the drastic reduction in precipitation and consequent drought in Southern Africa, South America, and South-Eastern Asia were associated with the Mount Pinatubo effect.[108] They warn that SRM has greater potential than the Pinatubo effect in bringing out dangerous results. Peter Brewer also shows how the Pinatubo effect gave rise to a series of related events like global cooling, reduction in agricultural productivity, famine, food riots and "hundreds of thousands of untimely deaths."[109]

The case of the other volcanic eruptions also underscore the varying regional impacts of such events and conversely of SRM climate engineering. Robock et al. have shown that tropical volcanic eruptions can cause changes in the atmospheric circulation resulting in winter warming in the Northern hemisphere.[110] The precipitation reduction can be up to 3.0 millimetres per day in the South-Eastern Asia, compared to a scenario without climate engineering.[111] Robock also argues that SRM can disturb the summer monsoons in Asia and

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[105] D. J. Lunt, A. Ridgwell,P. J. Valdes,A. Seale, "Sunshade World: A Fully Coupled GCM Evaluation of the Climatic Impacts of Geoengineering," *Geophysical Research Letters*35 (2008). Available at http://onlinelibrary.wiley.com/doi/10.1029/2008GL033674/full. Accessed April 9, 2015.
[106]G. Bala, P. B. Duffy, and K. E. Taylor, "Impact of Geoengineering Schemes on the Global Hydrological Cycle," *PNAS* 105 (2008): 7664-7669.
[107]Kevin E. Trenberth and Aiguo Dai 2007.
[108] Trenberth and Dai 2007.
[109] Brewer 2007, p. 9915.
[110]Alan Robock, "Volcanic Eruptions and Climate," *Reviews of Geophysics* 38 (2000):191–219; Georgiy Stenchikov et al., "Arctic Oscillation Response to Volcanic Eruptions in the IPCC AR4 Climate Models," *Journal of Geophysical Research* 111 (2006). 1-17. Available at http://onlinelibrary.wiley.com/doi/10.1029/2005JD006286/epdf. Accessed April 4, 2016.
[111] Robock 2008a.

Africa that would affect the food and water supply of millions.[112] Luke Oman et al. have shown that eruptions at high latitudes can weaken the Asian and African monsoons resulting in reduced precipitation.[113]

From the intersection between the predictions of the computer simulations of SRM and the Rawlsian understanding of distributive justice, we could deduce a number of conclusions. Firstly, as there is much consensus that the effects of SRM will be unevenly distributed from region to region, there will most likely be unequal distribution of the benefits and harms of climate engineering. That is to say, there will be losers and winners as a result of SRM. This violates the two fundamental principles of justice as fairness: "each person is to have an equal right to the most extensive scheme of equal basic liberties compatible with a similar scheme of liberties for others. Second: social and economic inequalities are to be arranged so that they are both …reasonably expected to be to everyone's advantage…"[114] In the climate engineering scenario, the liberty and freedom of a vast number of populations across the globe will be affected by the impacts of climate engineering. The impoverishment of one's natural background will certainly condition the social and political rights. Therefore, the principles of freedom and liberty which are necessary for a just system will be at stake. The natural conditions emerging from the climate engineering scenario are such that they cannot guarantee the secure protection of equal liberties. It can be seen that the SRM scenario also poses serious challenges, especially, to the second of the three components of liberty envisaged by Rawls,[115] i.e., the restrictions or limitations which people are free from. Rather than alleviating the existing limitations and restrictions, climate engineering only worsens it.

Secondly, dwelling on the second principle of justice as fairness, i.e., "social and economic inequalities are to be arranged so that they are both …reasonably expected to be to everyone's advantage…"[116] it could be seen that climate engineering would be an unfair deal as it inflicts misery to many by which *others* may reap benefit. Climate engineering is likely to create beneficiaries at the expense of forced benefactors. As Preston observes, "To the degree that the characteristics of an engineered climate can be predicted, choices will have to be made about *who* gets *what* in a geoengineered world. Clearly there are concerns that the

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[112] Robock 2008a.
[113] Luke Oman et al., "Climatic Response to High-Latitude Volcanic Eruptions," *Journal of Geophysical Research*110 (2005). Available at http://onlinelibrary.wiley.com/doi/10.1029/2004JD005487/full. Accessed on August 20, 2016; Luke Oman et al., "High-Latitude Eruptions Cast Shadow Over the African Monsoon and the Flow of the Nile," *Geophysical Research Letters*, vol. 33, (2006).
[114] Rawls, *Theory of Justice*, p. 53.
[115]See, Chapter 4, 4.3.3.
[116] Rawls, *Theory of Justice*, p. 53.

interests of the most powerful would be protected, while those less powerful will get secondary consideration (if they are considered at all)."[117] Morrow et al. articulate the irony of the favourable risk-benefit ratio analysis that they overlook the mismatch between the beneficiaries and those who would bear the risk.[118]The institutional dimension of the injustice hinted at by Rawls becomes predominantly significant in the context of climate engineering as any practice of climate engineering without proper homework would distribute the benefits and harms inequitably or in a manner that would violate the rights of some individuals.

Thirdly, the dialogue between Rawls and the ethics of climate engineering would call for re-emphasising the concept of natural primary goods in Rawls. If Rawls were to draft his theories in the climate engineering context, we are inclined to think that he would have dwelt at greater length on the notion of natural primary goods. For Rawls, the liberty for all is optimized by access to the primary goods, or the all-purpose-means. Rawls classified primary goods into natural and social, and, opined that natural primary goods are not under the control of the social institutions although social institutions can condition their achievement. However, the climate engineering scenario might significantly challenge the assumption that natural primary goods are not under the control of the social institutions. The climate engineering practice, as an invasive technique into the earth-system, does create a state of affairs where access to the natural primary goods like health, environment, etc., are defined and controlled by social and political institutions. For example, a designer climate by SRM techniques with reduced precipitation, as warned by the simulations, would certainly carry several health hazards. Therefore, the just distribution of social primary goods in climate engineering has to be built up on the foundational platforms of equitable natural primary goods. The long list of social primary goods necessary for a just society, given by Rawls like basic rights and liberties, freedom of movement, free choice of occupation, income and wealth, and self-respect, cannot be facilitated if sections of populations are deprived of their access to the natural primary goods through climate engineering.

Rawls' expanded idea of international distributive justice as developed in his *Laws of Peoples* is equally important for treating the concerns with distributive justice for a scientific technique like climate engineering exercised in a non-encapsulated system with trans-boundary applicability. The provisional list of principles laid down by Rawls to be followed by peoples, like respect for the freedom of people, respect for human rights, and duty of non-intervention carry direct implications for distributive justice in regard to climate engineering.

[117] Preston 2013, p. 30.
[118] Morrow et al. 2009, pp. 5-6.

Unprecedented levels of caution and care will be needed for abiding by the principles of non-intervention and respect for human rights for a novel technology like climate engineering with a global outreach. At the present range of technological development, it will be impossible for any nation to deploy SRM without intervening into the spatial and territorial integrity of the other nations and without causing any interference with the patterns of climate and life in that region.

4.4.2 Difference Principle and the Compound Injustice[119]

As discussed above, a uniqueness of the Rawlsian understanding of justice is the postulation of the difference principle. In its developed form, the difference principle holds that the benefits to the least advantaged group must be maximized,[120] and, "social and economic inequalities should be evaluated in terms of how well off they leave the worst off."[121] "Social and economic inequalities are to be arranged so that they are both (a) to the greatest benefit of the least advantaged…"[122] Invoking the difference principle in the context of climate engineering, we find that the net results of SRM will be diametrically opposed to the difference principle in all its three variants. Moreover, contrary to the call of the difference principle to make the most disadvantaged better off, SRM only impoverishes further the least well off and the most unfortunate. The "geographical bad luck"[123] that has conditioned the plight of the poor will be compounded by the side effects of climate engineering.

Rawls' understanding of the least advantaged in the society as those whose natural endowments permit them to fare less well, and whose fortune and luck in the course of their life turn out to be less happy,[124] is all the more relevant in the context of climate engineering. As primary natural and social goods and resources are the parameters for defining the worst off, it is clear that they are the poorest in the society. Ironically, in the context of climate change, the victims of climate change who have contributed very little to the causes of climate change are further made victims to bear the harms of proposed technological solutions to climate change like SRM. It would mean that climate change with climate engineering will be worse than climate change without climate engineering for populations

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[119] The phrase 'Compound Injustice' is of H. Shue 1992. Also see, Preston 2014, p. 79.
[120] J. E. J. Altham, "Rawls's Difference Principle," *Philosophy* 48 (1973), p. 75.
[121] Philippe Van Parijs "Difference Principles," in *The Cambridge Companion to Rawls*, p. 200.
[122]Rawls, *Theory of Justice*, p. 72.
[123] Preston 2014, p. 80.
[124]Rawls, *Theory of Justice*, p. 83.

like India and Bangladesh.[125]As Bunzl observes, "… the use of SRM as a mechanism of mitigation raises the possibility that … those already harmed by climate change … are made yet worse off by SRM…"[126] If we can rely on the data from computer simulations this could be the scenario that "roughly 10% of the World's population might be worse off even if the other 90% was better off."[127]Present estimations of the effects of climate engineering, however uncertain they may be, show a heavily skewed vulnerability towards harming some of the poorest populations of the world including the sub-Saharan region.

The report of the Solar Radiation Management Governance Initiative (SRMGI) warns that "SRM research could constitute a cheap fix to a problem created by developed countries, while further transferring environmental risk to the poorest countries and the most vulnerable people [...]"[128] The significant regional variability to the results of SRM is said to "pose a risk to local food security if subsistence farming prevails and adaptation is not possible."[129] The 2011 report of the Woodrow Wilson Center states that "[p]opulations living at the edge of subsistence—those with the least capacity to adapt to the impacts of climate change and almost no voice in international deliberations—are precisely the populations that will be most vulnerable to any negative side effects that geoengineering experiments may have […]."[130] These studies show that the various injustices related to climate change to which the global poor are already exposed are likely to be compounded by climate engineering.[131]

It is estimated that nearly 3.9 billion people in Asia live in rural areas and over one third within close distance (less than 100 km) off the coast.[132] Since water and agriculture would be most vulnerable to climate change and the consequent climate engineering, a huge population in the Asia-Pacific region is likely to be made worse off by climate engineering.[133] Therefore, the fear is that climate engineering might widen the socio-economic inequalities

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[125] Bunzl 2008.

[126] Bunzl 2009.

[127] Bunzl "Geoengineering and Equity," Bunzl's Blog, comment posted May 12, 2008. Available at http://ccspp.blogspot.com/2008/05/geoengineering-and-equity.html, comment posted May 12, 2008. Accessed November 5, 2014. Also see citation in Aaron Ray, "Alternative Responses to Climate Change: An Inquiry into Geoengineering," *Stanford Journal of Public Policy* 1:1 (2010): 35-50, p. 40.

[128] Solar Radiation Management Governance Initiative (SRMGI). Solar Radiation Management: The Governance of Research. Available at: http://www.srmgi.org/files/2012/01/DES2391_SRMGI-report_web_11112.pdf. Accessed on July 17, 2014, p. 21.

[129] J. Pongratz, D. Lobell, K. Caldeira, "Crop Yields in a Geoengineered Climate," *Nature Climate Change* 2(2012):1–5, p.3.

[130] R. Olson, "Geoengineering for Decision Makers," *Woodrow Wilson Center Report* November 2011. Available at: ttp://www.wilsoncenter.org/sites/default/files/Geoengineering_for_Decision_Makers_0.pdf. Accessed July 12, 2014, p. 39.

[131] See Preston 2013, p. 28; Shue 1992.

[132]See, Cruz et al. 2007.

[133] See, Prantl 2011.

already prevalent in the world. As Gardiner (2013c) comments, "…SSI (stratospheric sulphate injection) raises serious concerns about justice and the plight of the most vulnerable…."[134]

It becomes clear that the Rawlsian difference principle and the potential impacts of climate engineering are very much at loggerheads. As climate engineering runs contrary to the vision of justice envisaged by difference principle, this principle may present a strong case against climate engineering as it is presently conceived.

4.4.3 The Principle of Efficiency and Climate Engineering

As we discussed above, Rawls takes recourse to the principle of efficiency in developing his notion of justice. According to the principle of efficiency, a system cannot be said to be efficient if there is an alternative arrangement that could improve the situation of some people without rendering the situation of any of the other people worse.[135] As for Rawls, any unequal distribution of social values is justified if only such an arrangement is to everyone's advantage. It is our contention that the principle of efficiency and climate engineering are incompatible at least on two counts. Firstly, the foregoing discussions have shown that climate engineering would certainly cause a differentiated distribution of harms and benefits and such a distribution is not justifiable as it would not be to everyone's advantage, rather it only causes more harm to the most disadvantaged. Secondly, the possibility of alternative arrangements, like mitigation and adaptation, for tackling climate change that could improve the situation of some people without making the situation of any other people worse further confronts climate engineering on the ground of the principle of efficiency.

This takes us back to the discussion on the status of climate engineering as Plan A or Plan B, a theme upon which we dwelt at some length in the third chapter of this study.[136] In the overall debate, there is a hidden framing of the status of climate engineering, treating this technology as a Plan B - a supplementary tool facilitating the efforts of mitigation and adaptation - as a possible insurance policy against climate change. In this approach, climate engineering forms synergies with mitigation and adaptation in tackling climate change.[137] Another approach in regard to the status of climate engineering is to treat it as a last resort

[134] Gardiner 2013b, p. 28.
[135] See http://www.ohio.edu/people/piccard/entropy/rawls.html. Accessed on 10-11-2014.
[136] See Chapter 3, 3.4.2.2.
[137] See, MacCracken 2006, p. 241; Amelung, p. 41; Thilo Wiertz, in Amelung; Goodell, 21; Greene et al. 2010, 22; NERC 41; Royal Society, 2009.

option. As reflected in the optimism of Lenton and Vaughan: “[s]trong mitigation, combined with global-scale air capture and storage, afforestation, and bio-char production, i.e. enhanced CO_2 sinks, might be able to bring CO_2 back to its pre-industrial level by 2100, thus removing the need for other geoengineering.”[138] The principle of efficiency does seem to be reconcilable with the primacy of mitigation and adaptation in combating climate change. As Keith et al. (2010) have warned, “it is vital to remember that a world cooled by managing sunlight will not be the same as one cooled by lowering emissions.”[139] The principle of efficiency would imply that irrespective of the practical challenges, a firm commitment to mitigation with due political will and determination would be the natural course of action in combating climate change, especially as there are serious issues of justice at stake in climate engineering. Although, the entire complexity of the ethical polyvalence of climate engineering cannot be subsumed into the principle of efficiency, it raises disturbing concerns from the subaltern perspective about the drastic consequences of the pragmatic adjustments that we uncritically propose in combating climate change.

4.4.4 The Rawlsian Perspectives on CDR Approaches

As we have noted already, most of the discussions on climate engineering and distributive justice are confined to SRM techniques. The CDR approaches are almost absent from the scene. However, it does not mean that CDR approaches are freed from the vulnerabilities of SRM. CDR techniques, too, have the potential to increase benefits for some whilst by increasing harms for others. The net result of the CDR techniques are also said to be unevenly distributed and weakening the case of the vulnerable populations of the world.[140] For instance, many of the consequence of ocean acidification, one of the schemes under CDR, will have direct impact on the lives of the fisher-folk. Ocean acidification could lead to reduction in the fish yield from the ocean. As we have seen, one third of the population in Asia is living on the coastal areas with ocean as the main source of sustenance. Thus CDR also faces obstacles in meeting the requirements of the various principles of distributive justice in Rawls.

[138] Lenton & Vaughan 2009. Cited in Banerjee 2011, pp. 16-17.
[139] Keith et al. 2010, p. 426.
[140] Svoboda et al. 2011.

Yet another instance of the CDR techniques being a challenge to distributive justice is the area of agriculture and food ethics.[141]"Furthermore, mitigation and adaptation measures to counter or slow down climate change have already resulted in considerable changes in agri and silvicultural land-use. This is, among important other reasons of environmental decline, due to the significant increase in growing plants for energy supply ('biofuels'). Another perspective is the purchase or long-term tenancy of arable land or of water rights in the countries of the global south by wealthy nations and by transnational enterprises."[142] This observation, e.g. byThomas Potthast et al. (2015), is only likely to be aggravated by some forms of CDR techniques. Considering biomass and biofuel to be falling under the category of CDR techniques and the possibility of huge amount of cultivable land being diverted for such purposes may adversely impact the fate of justice in the agriculture sector. Kortetmaki and Oksanen (2016) have argued that more procedural injustices and greater threat to food security arise even under CDR climate engineering than under mitigation and adaptation.[143] Similarly, in regard to ocean upwelling and downwelling it has been feared that there are non-local impact of the exercise. Upwelling on one side of the ocean being compensated by an upwelling on the other side of the globe might distort the carbon equilibrium,[144] which in turn could affect the ocean yield and the sustenance of the fisherfolk.

4.5. Recommendations

Employing the Rawlsian principles of freedom and liberty, his principle of efficiency and his difference principle to the debate on climate engineering may appear to suggest a negative assessment of climate engineering on the grounds of justice. The Rawlsian frame of justice may not endorse climate engineering as it is conceived now. The limitations of applying a social theory of justice, as of Rawls, to a natural context like climate engineering also become vivid in the intersection between Rawls and climate engineering. However, a rejection of climate engineering from the viewpoints of Rawls may be only apparently and deceptively true. A proper accommodation of the principles and values of justice advocated by Rawls into the climate engineering debate is helpful for the maturation of the debate in

[141] For a brief discussion on the implications of climate change and sustainable development for land use and food production see, Thomas Potthast et al., "Introduction," *Journal of Agriculture and Environment Ethics* (2015) 28:407–412.
[142] Potthast et al. 2015, p. 408.
[143] Teea Kortetmaki and Markku Oksanen, "Food Systems and Climate Engineering," in Christopher J. Preston, ed., Climate Justice and Geoengineering – Ethics and Policy in the Atmospheric Anthroposcene (London, New York: Rowmand and Littlefield, 2016), pp. 146-160.
[144] Royal Society 2009, p. 19.

very many ways bringing the issues of justice to the forefront. It can be helpful in reorienting the priorities and emphases of the debate as it cautions against the hitherto undeveloped or less developed aspects of the debate.

Our preceding discussion shows that climate engineering as envisaged in the present manner is almost incompatible with the principles of distributive justice outlined by Rawls. We need to see further whether climate engineering can be developed and applied whilst complying with Rawls' ideas and principles of justice, both intra-nationally and internationally. Towards this, we shall try to suggest some new directions and fresh additions to the climate engineering debate that would make it more compatible with the principles of distributive justice intra-nationally and internationally.

4.5.1 Research Agenda Focused on the Vulnerable

On the scientific part, there seems to be lopsidedness in some simulation models to the flowery aspects of climate engineering by ignoring the inputs with adverse impacts. This needs to be rectified. As many climatologists have suggested, inputting the adverse impact events into the earth-system models and computer simulations[145] is vital for the proper assimilation of the principles of distributive justice. Tuana et al. have opined that the present earth-system models are inadequate in giving proper information on crucial geophysical factors in climate engineering that are very essential for assessing the issues of distributive justice like long time scales, differences in regional impacts, and the potential low-probability/high impact events.[146] Their proposal of a specific research agenda that would analyse comprehensively the social and physical impacts of SRM with particular focus on their benefits and harms[147] will be a significant step towards better appreciating the issues of distributive justice. The guidelines for the researchers from the perspective of justice, offered by Morrow et al. (2009),[148] after analysing the consequences of the climate engineering research beyond the computer models, are worth revisiting here. According to them, the principles of beneficence and justice warrant the favourable risk-benefit ratio, fair distribution of risks and anticipated benefits, and protection of the basic rights of affected individuals.[149]

[145]G. A. Meehl et al., "Global Climate Projections," in S. Solomon et al., Eds., *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, UK and New York, USA: Cambridge University Press, 2007); Keller et al. 2007; Urban & Keller 2010.
[146] Tuana et al. 2012, p. 142.
[147] Tuana et al. 2012 p. 144.
[148]Morrow et al. 2009.
[149] Morrow et al., 2009, p. 1.

Hence the greatest attention of the researchers should be on those who bear the risk and gain little. Accordingly, they also advocate a maximin approach for risk-benefit assessment whereby researchers should try to minimise the risks to the maximum to those whose welfare will be affected by the research.[150]

4.5.2 **Addressing the Intricacies of Compensation**

If climate engineering becomes an indispensable option in future, the issue of compensation becomes very crucial. Gardiner (2010b) laments that in the public and political discussion of climate engineering there is virtually no mention of compensation or global justice.[151]Although there is mention of compensation by several authors, our review found only one paper that ventures seriously into the concrete intricacies of compensation in climate engineering.[152] Ensuring the rights, liberty and self-respect of those who bear the harms of climate engineering is a prelude to any research programme in climate engineering. It is a challenging task for climate engineering ethicists to ensure that the “geographical bad luck” of the unfortunate victims of climate change is not compounded, but compensated by climate engineering. There should be compensation of extra costs triggered by negative side effects of climate engineering. The differentiated causal responsibility for the harms on whom the obligation falls, identifying the true victims, the legal framework and moral imperatives for compensation, the measurement and the modes of compensation including rehabilitation, etc., are still undeveloped issues in the present phase of the debate. It is an irony that the cost-benefit analysis of climate engineering does not include the parameters of compensation. Redefining the cost-benefit calculus may challenge the “incredible economics of climate engineering” with such artificially hyped ratio of 1:100.[153]

4.5.3 Developing the Political Determination

The discussion on justice in climate engineering is, to some extent, one of the political dimensions of the climate engineering debate. As the present research is mostly confined to the scientific and social aspects of the issue, it is necessary that due political interventions are incorporated into the debate from its early phases. The poor treatment of the issues of justice in climate engineering, let alone distributive justice, by formal bodies like IPCC and Royal Society may be partly due to the lack of the political awareness on the issue. Probably, this

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[150] Bunzl 2007.
[151]Gardiner, 2010b, p. 17.
[152] See Bunzl 2011.
[153] See Barret 2014.

state of affairs is partly due to the fact that the present trend of engagement with climate engineering is mostly at the scientific and technological level, and the concerns with ethics are still confined to the ethicists and philosophers. The climate engineering scientists, social scientists, political think tanks and policy makers are still to apply themselves seriously to this emerging challenge. Hence the maturation of the justice concerns in the debate is possible only with the proper integration of the political and social ramifications of the climate engineering technologies. The political will must apply itself to adequately developing the ethical, legal and social implications of climate engineering from the early phases of the climate engineering researches.

4.5.4 Revised Conceptions of Rights and Obligations

Given the force of the challenges to justice in climate engineering, ensuring distributive justice would require broad range of policies, measures and activities that are perhaps hitherto unprecedented in international relations, practices and treaties. Insulating climate engineeringagainst compounding the climatic injustice further may need broadening the very moral concepts of rights and obligations. Rich and affluent societies and nations of the world should be more accountable for the historical and relational dimension of their present well-being and be held more responsible for the ecological impacts of their affluent ways of life including the overshoot with their eco-footprint. Rights and obligations of nations and societies should be reconceived within such a wider historical and ecological matrix. For instance, although the present rate of carbon emission of a particular country (say, Britain) may not be beyond the stipulated limits, its historical progress through industrialisation may have already contributed to the compounded climatic injustice to which the poor nations of the worlds are presently exposed to.

The estimate of the World Resources Institute is that from 1950 to 2000, 90% of the CO_2 emission has been produced by just 25 countries.[154] Therefore, understanding the rights and obligations of the poor and rich nations in the context of climate engineering cannot be defined within the present time frame alone. In the climate engineering case, rights and obligations should be appropriated also within the historical and futuristic setting of climate change. The intuitive norm for justice in climate engineering should be that the rights of those

[154]See K. A. Baumert, T. Herzog and J. Pershing, Navigating the Numbers: Greenhouse Gas Data and International Climate Policy. Available at http://pdf.wri.org/navigating_numbers.pdf. Accessed October 30, 2015.

who have contributed little to climate change, but are most vulnerable to the climate change and to the harms of climate engineering deserve privileged protection. This norm should be a binding obligation on those who have contributed to the climate change. Therefore, there can be no build-up of distributive justice in climate engineering without specifying the specific obligations on the rich nations, though deciding the proportions in this regard may be very complex. The prophetic value in Preston's fear deserves appreciation: "Given the uncertain future ahead in a warming world, the concepts of obligation and responsibility may be neither broad enough nor flexible enough for the demands that climate change and SRM will make."[155]

Along with the normative force of rights and obligations, an appreciation of the moral concept of 'desert' would be an added protection for justice in climate engineering. Desert is a moral concept introduced by Sher (1987). Desert is "central to our pre-reflective thought."[156] Desert is the intuitive view that some particular groups or persons *deserve* more while some others do not. For example, a hardworking student deserves to score more. Preston thinks that, "At this pre-reflective level, it seems likely that the developing nations do not *deserve* the hand that climate change and the prospect of SRM deals them."[157] The point about desert may be the hermeneutical force of the need for "… more conscience"[158] in climate engineering advocated by Svoboda et al. (2011). Concerns of distributive justice in climate engineering should be addressed both under the direct obligations and matters of desert. Preston (2014) thinks that financial compensation and logistical support with adaptation would fall under the direct obligations and new immigration policies and technology transfer would be matters of desert.[159] Formulating an international calculus for the skewed responsibilities and differentiated causal obligations of climate change and apportioning the compensation to the vulnerable nations among the rich nations against such a calculus may be a viable step to assuring justice in climate engineering.

4.5.5 Reliable Forecasts and Contingency Plans

As the clouds of several scientific uncertainties are still looming over the techniques of climate engineering, the "Extreme vigilance, and more conscience"[160] advocated by Svoboda

[155] Preston 2014, p. 84.
[156] G. Sher, *Desert* (Princeton, New Jersey: Princeton University Press, 1987), p. ix. See also Preston's treatment of the concept of Desert in Preston 2014, pp. 83-86.
[157] Preston 2014, p. 84.
[158] Svoboda et al. 2011.
[159] Preston 2014, p. 87.
[160] Svoboda et al. 2011.

et al. (2011) become the imposing imperative for climate engineering. As there are several forecasts expressing the fear that the plight of the global poor will be worsened by climate engineering, alleviating the uncertainties in regard to the side effects of climate engineering is necessary for initiating the proper measures to ensure justice. Reducing the uncertainties and refining the scientific proofs and evidences is necessary for developing policies and structures for ensuring distributive justice in climate engineering. The awareness of the grave limitations of the computer simulations in climate engineering tests deserves special scientific attention.

As the issue of who would bear the burden of proof is still open in the debate, due recognition of Rawls' principles of justice would demand that proponents of climate engineering should assume the burden of proof in regard to the impacts and side-effects of climate engineering, alleviating the scope for unexpected harms as much as possible. Accordingly, the vulnerable regions and nations should be equipped and empowered to stand up to any foreseen or unforeseen, known or unknown side effects of climate engineering. Raising a contingency fund for financial aid to the vulnerable nations, providing logistical support with adaptation, relaxed immigrations rules towards ecological refugees, technology transfer to the poor nations, and contingency plans for rehabilitation are some of the ethically warranted practical measures and preparations to ensure distributive justice.[161]

4.5.6 Greater Regional Engagement

The predicted regional imbalance in the benefits and harms of climate engineering invites improvements upon the present format of the debate. It is highly commendable that though there are presently no authors from those regions that are potentially most vulnerable to climate engineering, European and American authors like Svoboda, Gardiner, Preston, Prantle, etc., have forcefully pushed the concerns of the disadvantaged regions to the forefront. However, the contextual proprieties in the debate demand that ethicists, policy makers and social analysts from the vulnerable regions of the world be engaged more extensively and substantively in the climate engineering debate. Historically, there were several instances where the initial neutrality of the scientific research was eventually skewed

[161]See Preston 2014, p. 87.

towards the legitimisation of self-interest.[162] As many have suggested, concerns with distributive justice demand that there be more social interdisciplinarity[163] and regional interaction in climate engineering policy-making.

4.5.7 Exploring the CDR Impacts

The debate on distributive justice is extremely skewed towards the analysis of SRM technologies with practically little attention paid to distribution of the harms or benefits of CDR approaches. However, the irony is that Royal Society and IPCCare recommending CDR schemes to begin with. If such recommendations are accepted, there is the likelihood that the CDR methods are deployed with inadequate homework done. That is to say, as the attention of the ethicists is now focussed on SRM, they may be ill prepared to address the challenges emerging from the deployment of CDR methods. The lack of political awareness about distributive justice in climate engineering is further corroborated by this situation. It is recommended that more scientists and ethicists study the implications of the various CDR techniques for distributive justice.

4.5.8 New Legal Frameworks

As Rawls has commented, institutions also can be channels of injustice if they produce social benefits and distribute these inequitably or in a fashion that violates the rights of some individuals. Ensuring distributive justice in climate engineering would entail a critical introspection at the various international laws, protocols, treaties and guidelines (for example, the Kyoto Protocol or the UN treaty on Biodiversity) as to whether they become channels of institutional injustice or structural violation of rights. The concerns with justice in climate engineering may not be feasible without formulating new international laws and protocols. Probably, for the first time, international bodies are confronting a potential technology with such long-term impacts and planetary outreach. Climate engineering schemes, if deployed, will be ranging beyond territorial and national boundaries. Thus the socio-political consequences of this technology would be unprecedented. Hence, ensuring distributive justice would entail developing new legal frames. Even a quick overview of the justice concerns in climate engineering shows that it invokes “the need for new or strengthened

[162]See, Stephen J. Gould, *the Mismeasure of Man* (New York: W. W. Norton, 1981); R. Bleir, *Science and Gender: A Critique of Biology and its Theories on Women* (Elmsford, New York: Pergamon Press, 1984).
[163]Meehl et al. 2007; Keller et al. 2007; Urban & Keller, 2010.

global norms of justice and community, and novel institutions…”[164] As Ray (2010) has observed, “… at the moment, we lack a credible means of deciding global questions of distributive justice.”[165] The recognition of the ‘differential responsibilities’ for the anthropogenic climate change in the United Nations Framework Convention on Climate Change is a right step in this direction, to be followed up with due seriousness in the climate engineering context. As of now there is internationally a juridical missing link in deciding which risks and harms are acceptable and in which manner. The need for new legal frames is all the more important in the wake of the increasing presence of the private stakeholders with profit-driven motives on the climate engineering scene.

4.6 Conclusion

This chapter constitutes the first of the three normative chapters on climate engineering and justice. In this chapter we have dealt exclusively with the issues of distributive justice in climate engineering. Our concern was to see the challenges that climate engineering pose to distributive justice and to see the conditions of distributive justice, mostly from the Rawlsian perspective, under which climate engineering may be desirable. In the first part of this chapter, we reviewed the current literature on distributive justice in climate engineering. In the second part, we looked for a normative and conceptual ground for examining the concerns of distributive justice in climate engineering and we identified the views of Rawls as relevant for this discussion. Having highlighted the principles of justice in Rawls’ work, in the third part, we applied those principles to see climate engineering from the point of view of distributive justice. Analysing the side effects of climate engineering in the light of Rawls’ principles of distributive justice, we saw that climate engineering faces obstacles in meeting the requirements of the principles of distributive justice. The prevalent uncertainties in the assessment of risk and harm associated with climate engineering are also swinging more towards worsening the plight of the global poor. In the light of the vivid challenges to distributive justice, we also made some recommendations for advancing the debate on climate engineering with due recognition of the principles of distributive justice. The main message of the chapter is that as of now the climate engineering proposals do not meet the requirements of distributive justice as they are mostly pro-rich and the fundamental condition for ensuring distributive justice is to make climate engineering as much poor-friendly.

[164]Gardiner 2011.
[165] Ray 2010.

This chapter has addressed the first part of our research question, that is, can climate engineering be just compatible with the Rawlsian principles of distributive justice. Now in the following two chapters we will take up the second and third part of the research question respectively on intergenerational and procedural justice, with the next chapter dealing precisely with the issue of intergenerational justice.

Chapter 5

Intergenerational Justice in Climate Engineering

5.1 Introduction

Exactitude and precision, essential characteristics of any scientific knowledge, cannot be fully claimed by the climatic sciences especially in matters of prediction. It is still difficult to predict scientifically the full spatio-temporal outreach of a natural climatic development or a deliberate climatic intervention. The climate of a region or of a period is the result of a series of geographical factors and processes spanning over hundreds of years. Geographical history underscores that impacts of any intervention in the earth's climate in a particular period or region will not be confined to that period or region alone. Instead its long-term impacts are likely to be effective for generations to come. True to this concern, ethicists have vociferously warned on the challenges posed by climate engineering to future generations. While the spatial imbalances and inequalities emerging from climate engineering interventions constituted the questions of distributive justice that we discussed in the previous chapter, the temporal impacts invoke yet another crucial element in the ethics of climate engineering, that is, the issue of intergenerational justice.

Intergenerational justice involves the distribution of the benefits and harms between the present generation and the future generations. No generation has unlimited entitlements to natural resources; each generation also has certain obligations as a custodian of natural resources which are to be preserved for the well-being of the future generations. Accordingly, intergenerational justice plays a role in most theories of ethics, and it finds major inroads into the international treaties and conventions.[1]Intergenerational justice forms one of the fundamental principles in debates concerning sustainable development.[2]Justice concerns in

[1] Amazonian Cooperation Treaty preamble, July 3, 1978, I.L.M. 1045; Convention on Biological Diversity preamble, paragraph 23, 1992, 1760 U.N.T.S. 79, 31 I.L.M. 818; Convention on the Conservation of European Wildlife and Natural Habitats preamble September 19, 1979, 1284 U.N.T.S. 209; Convention on the Conservation of Migratory Species of Wild Animals preamble, June 23, 1979, 1651 U.N.T.S. 356, 19 I.L.M. 15, etc. Burns observes that that the UNFCCC is the only treaty that includes intergenerational equity considerations in non-preambular provisions (See Burns 2013, p. 209). Intergenerational equity principles are also incorporated into the first paragraph of the United Nations Charter ("We the peoples of the United Nations, determined to save future generations from the scourge of war...."). U.N. Charter preamble.

[2] Organisation for Economic Co-operation and Development (OECD), National Strategies for Sustainable Development: Good Practices in OECD Countries, SG/SD(2005)6, para 16. Available at http://www.un.org/esa/sustdev/natlinfo/nsds/egm/crp_9.pdf, Accessed on April 13, 2015; U.N. Conference on Environment and Development, Rio de Janeiro, Brazil, June 13, 1992, Report of the United Nations Conference on Environment, U.N. Doc. A/CONF.151/26 (vol. 1) (Aug. 12, 1992); U.N. Env't Prog., Final Report of the

climate engineering warrant serious analysis of the just distribution of benefits and harms among the present and future generations. Understandably, ethicists have repeatedly raised the issues of intergenerational equity in climate engineering.[3] As we discuss below, the dangers of sudden termination, the polluter-pays principle, moral hazard, the treatment of the symptom over the cause, and the risk transfer issue, are the major challenges to intergenerational equity in climate engineering.

For methodological integrity, here too, we evaluate the issue of intergenerational justice against the theoretical frame of John Rawls. Accordingly, our lead question in this chapter is: what are the conditions of ethical research and application of climate engineering technologies as seen from the perspective of the Rawlsian view on intergenerational justice? Before venturing into the Rawlsian view of intergenerational justice, first we shall present a brief review of the academic literature on intergenerational justice in climate engineering. Next, drawing on the principles and perspectives of intergenerational justice in Rawls, we shall apply them to climate engineering. We shall conclude with some recommendations from the point of view of intergenerational justice from the Rawlsian perspective.

5.2 Review of Literature

5.2.1Ethical Concerns

As we have seen in chapter three, there are 13 papers[4] dealing with the issue of intergenerational justice in a manner worth mentioning. Among these, the paper by Burns (2013) directly and exclusively deals with the issue of intergenerational equity and other papers have only a subsection or passing reference to intergenerational justice. We shall present below a short picture of the various issues related to intergenerational justice in the present literature on climate engineering.

5.2.1.1 Current Generation on Trial

A glance at the literature on intergenerational justice shows that concerns about the unequal distribution of harms and benefits between the present and future generations are strongly voiced. Most authors aggressively hold the present generation responsible and

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Expert Group Workshop on International Environmental Law Aiming at Sustainable Development, UNEP/IEL/WS/3/2 (1996), 13-14, para 30, 44-45.

[3] See Chapter 3; 3.3.2.5.

[4] Bodansky 2013; Gardiner 2007; Jamieson 1996, p.330ff; Burns 2011, p.41ff; Gardiner 2013b, p.30f; Goes 2010, p.1; Leal-Arcas and Filis-Yelaghotis 2012, p. 130; Hale Benjamin 2012, p. 19; Preston 2013, p. 31; Gardiner 2006, p. 408; Gardiner 2010, p. 304; Svoboda et al. 2011, p. 22; Royal Society 2009, p. 276.

accountable for its policies and actions in regard to climate change.[5] Risk-transfer, polluter-pays, and responsibility abdication are the intergenerational ethical challenges highlighted by various authors.[6] Goes et al. (2010) and Burns (2013) think that SRM would fail in the ethical test, as it would violate the principles of intergenerational justice.[7]It is alleged that the present generation creates undue benefits for themselves by transferring the risks and burdens of climate change to future generations. This may be called the risk-transfer argument.[8]The polluter-pays principle accompanies this argument. This principle, formulated by Betz and Casean (2012), holds that those who cause the problem of climate change should also solve it.[9] Abdicating our responsibility for climate change and evading our responsibility in combating it is a kind of injustice to future generations. Hale (2012) calls it the responsibility abdication objection.[10] In this argument, climate engineering acquits us of our responsibility for our actions. It means that we can get away with our offences without being held responsible for them. The get-out-of-jail-free card argument – an argument we have discussed in chapter three[11] - also goes along with it.

5.2.1.2 Moral Hazard

Many authors view climate engineering as watering down the efforts at mitigation. This is technically termed as "moral hazard". A similar phrase coined in the literature is "get out of jail free" card.[12] Although moral hazard is a major ethical issue that is extensively discussed in the climate engineering debate, here we consider only those papers dealing with moral hazard as challenge to intergenerational justice. It is feared that future generations will be paying the price for the moral hazard caused by climate engineering. Further, the danger of moral hazard can be increased by the economic feasibility of climate engineering claimed by the proponents. Some estimates claim that even a single nation can develop and deploy climate engineering techniques.[13]The false hope given to the present generation that there is a

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[5] See Chapter 3, 3.3.2.5.
[6] See Chapter 3, 3.3.2.2 & 3.3.2.5.
[7] See, Goes et al. 2010; Burns 2013.
[8] Goes et al, p. 1.
[9] Jamieson 1996, p. 331.
[10] Benjamin 2012, p. 19.
[11] See Chapter 3; 3.3.2.5.
[12] Burns, p. 209 Royal Society 2009, p. 276.
[13] The cost of many geoengineering options might be "well within the budget of almost all nations," as well as a handful of wealthy individuals. Katharine Ricke et al., Unilateral Geoengineering: Non- technical Briefing Notes for a Workshop at the Council on Foreign Relations 4 (2008). Available at http://d1027732.mydomainwebhost.com/articles/articles/cfr_geoengineering.pdf; see also Lin (2012). Accessed August 18, 2014.

technical solution available and that too at a cheap rate does undermine the present attempts at mitigation. This puts future generation in greater trouble.

Gardiner (2006) finds yet another problem resulting from the moral hazard. The hope that there is a solution can lead the present generation in easily avoiding its moral obligations in relation to climate change. Gardiner (2006) forcefully attacks the evasive loopholes that each generation is likely to solicit in avoiding the moral obligations with regard to climate change. The intergenerational nature of the climate change, the geographically dispersed nature of its agents and its effects, the scientific uncertainties, etc., are some of our justifying weapons against our otherwise clear moral obligations. For Gardiner (200), climate change is the type of problem that "provides each generation with the cover under which it can seem to be taking the problem seriously … when really it is simply exploiting its temporal position."[14] He considers climate engineering as a mask for a number of vices. These vices include moral corruption, laziness and buck-passing, as well as knowingly putting the future generation that would actually initiate climate engineering in an undesirable position. The decision to pursue research in climate engineering shows that we have "failed to take on the challenge facing us, and instead have succumbed to moral corruption. Indeed, the decision to geo-engineer might reveal just how far we are prepared to go to avoid confronting climate change directly, and this may constitute a tarnishing, even blighting, evil."[15]

5.2.1.3 Termination Problem

While there are several aspects to the termination problem in the wider spectrum of the climate engineering debate,[16] here we mention only those papers dealing with the termination problem in relation to future generations. There is almost a consensus in the literature regarding the termination problem as the most difficult challenge at stake in climate engineering to intergenerational justice.[17] The point of the termination problem is that future generations will be forced to continue with a strategy for which they are not responsible and which they have not initiated. The termination problem restricts their freedom of choice in the future. Further, if SRM has to be discontinued for unforeseen reasons or even for policy matters, it can lead at worst to the extinction of the human species itself. Svoboda et al. (2011) have done significant work relating to the termination problem and intergenerational

[14] Gardiner 2006, p. 408.
[15] Gardiner 2010, p. 304.
[16] See Chapter 3; 3.3.2.3.
[17] Svoboda et al. 2011; Burns 2013.

justice. Using the theoretical models of Rawls (1999), Dworkin[18] (1981), Wigley[19] (2006) and Sen[20] (1982), they show how the effects of termination will have an adverse impact on intergenerational justice. They conclude that it violates the principles of intergenerational equity in all these models. According to them, "... intergenerational justice requires the present generation to ensure that future generations have access to food, water, shelter, and education.... any generation that implements SAG [Sulphate Aerosol Geoengineering] accepts the risk that it might later be discontinued, but the subjects of this risk are the future generations who would suffer the harmful effects if SAG should be discontinued abruptly."[21] The long-term impact of SRM is a major concern discussed in the literature. As per scientific estimations, once launched SRM may have to be continued for 500-1000 years; therefore, it poses disturbingly long-term challenges to the values and interests of future generations. It is also feared that policy decisions or ethical reasons may lead to abandoning SRM.[22]

5.2.1.4 Prevalent Uncertainty

The prevalent scientific uncertainty in determining the impacts of climate engineering in the future is a concern shared by two authors.[23] Determining to what precise extent a future burden is the consequence of a 'natural' weather event, of anthropogenic climate change, or of climate engineering will be next to impossible. As of now we could only speculate as to how many generations will be exposed to the impacts of climate engineering. Benefits and burdens are also likely to fall more upon future generations - whose number and identity are not yet known-than on the present generation.[24] The concern with scientific uncertainty thus invokes the issue of the methodological constraints in assessing intergenerational justice in climate engineering.

5.2.1.5 CDR and Intergenerational Justice

There is a discussion in just two paragraphs on CDR methods in relation to intergenerational justice in one of the papers.[25] It is true that CDR avoids the termination

[18] R. Dworkin, "What Is Equality? Part 1: Equality of Welfare," *Philosophy and Public Affairs* 10 (1981a): 185-246; "What Is Equality? Part 2: Equality of Resources," *Philosophy and Public Affairs* 10 (1981b): 283-345.
[19] Wigley 2006: 452-454.
[20] Amartya Sen, "Equality of What?" in Amartya Sen, Ed., *Choice, Welfare and Measurement* (Cambridge: Cambridge University Press, 1982).
[21] Svoboda et al. 2011, p. 22.
[22] Svoboda et al. 2011.
[23] Gardiner 2006; Preston 2013.
[24] Preston 2013, p. 31.
[25] Burns 2013.

problem and may be considered to be addressing the root of the problem rather than the symptom. The bright side of the CDR approaches for intergenerational justice is that it does not involve any threat of the danger of sudden termination as in SRM scheme. However, CDR schemes are not freed from the issue of moral hazard as it can downplay the efforts at mitigation by the present generation. Burns (2011) observes that compromising with mitigation means the responsibility for averting the dangers of climate change is transferred to the future generations. Further, CDR techniques need to be deployed in a sustained manner. It "would deny them (future generations) the full panoply of options that the principle of intergenerational equity demands."[26] Thus CDR schemes also pose challenges to intergenerational justice. However, he observes that compared to SRM, CDR challenges may be less pressing from the point of view of intergenerational justice.[27]

5.2.1.6 Theoretical Perspectives Applied

Though no author dwells significantly on any particular theoretical model, there are passing references to various theories of intergenerational equity in the literature. The models include Rawls (1999), Dworkin (1981), Wigley (2006), Sen (1982) and Weiss (1989). Svoboda et al. (2011) use Rawls (1999), Dworkin (1981), Wigley (2006), Sen (1982) and Weiss (1989). They also have a quick recourse to utilitarian theory. Burns (2011) uses mostly Weiss's perspective and concludes that termination problem would violate the second principle of intergenerational equity outlined by Weiss, that is, conservation of quality.[28]The notion of "original position" in Rawls,[29]the "social contract" theory of Edmund Burke,[30] the notion of "unjust enrichment" in Shelton[31] the "public trust" doctrine in E. B. Weiss,[32] the freedom of choice in UNESCO Declaration on Responsibilities of the Present Generations Towards Future Generations,[33]Dworkin's view of persons having an initially equal share of resources,[34]Sen's capability approach,[35]Arneson's view of all persons having an equal chance for welfare,[36]and desert-based theory of intergenerational justice[37] are the other theoretical

[26] Burns 2013, p. 218.
[27] Burns 2013, p. 218.
[28] Burns 2013, p. 213.
[29] Burns 2013, p. 205; Svoboda et al. 2011, p. 24.
[30] Burns 2013, p. 205
[31] Burns 2013, p. 205
[32] Burns 2013, p. 206.
[33] Burns 2013, p. 206.
[34] Svoboda et al. 2011, p. 24.
[35] Svoboda et al. 2011, p. 24.
[36] Svoboda et al. 2011, p. 24.
[37] Svoboda et al. 2011, p. 24.

frames used in assessing the issue of intergenerational justice in climate engineering by various authors. Interestingly, the conclusion in all these accounts is that climate engineering is problematic from the point of view of intergenerational justice.

5.2.2 Some Observations on the Debate

Most authors are inclined to look at climate engineering as a challenge rather than as an opportunity, as reflected in Burns' (2013) formulation that SRM "sows the seeds of a major peril for future generations."[38] There is an excessive preoccupation with the perils of SRM for intergenerational equity and no author seems to explore the scope for the justification of climate engineering from the intergenerational point of view. Thus the incompatibility of climate engineering and intergenerational equity is almost a foregone conclusion in the debate such as those pointing out that1) climate engineering is fairer than mitigation, 2) it buys time for mitigation, and 3) it fulfils our responsibility to future generations.The dangers of climate engineering seem to be an unquestioned premise upon which the ethicists begin their evaluation of climate engineering. Perhaps, any opportunity that climate engineering may provide to future generations, for instance, developing a ready-technology against all the odds of climate change, does not seem to be catching the attention of the ethicists. However, there is some vindication in this regard in Preston (2011), who thinks that at the end of the day, it may be a lesser evil.[39]

Although there are several objections to climate engineering from the intergenerational justice point of view, the debate landscape does not reflect a serious engagement with the proponents of climate engineering who hold that it may be exercised in a manner that would comport with the norms of intergenerational justice. A major exception in this regard is the commendable engagement made by Burns (2011) who confronts the claims of the proponents that it shields the future generations from future disasters and thereby we fulfil our obligations to the future generations. Burns (2013) considers this argument as a false dichotomy of choices created between our failure to initiate meaningful measures to curtail emissions and our use of climate engineering as a bandage to cover the wound inflicted upon the future generations resulting from our failure.[40] Burns (2013) also

[38] Burns 2013, p. 209.
[39] Preston 2011.
[40] See Burns 2013, p. 218.

questions the buying-time argument of the proponents that climate engineering will allow enough time for mitigation strategies by calling for alternatives that can help us buy time.[41]

The overemphasis on the termination of SRM and inadequate attention paid to the CDR technologies seem to be two unbalanced areas in the debate. The focus on the termination effect is deservingly significant. However, it has almost hijacked the debate to the extent that it practically ignores the equally important concerns like the argument of lesser evil and the concern of moral hazard that would deserve greater attention. More scientific details of the CDR techniques are to be analysed for a balanced assessment of its implications for intergenerational equity. The present discussion on CDR identifies only pragmatic concerns of governance as a real challenge, which alone is no convincing reason for ruling out CDR. On a critical scrutiny of the review of literature, it seems to be insufficiently developed. Thus the topic of intergenerational justice and climate engineering warrants a more exhaustive analysis.

5.3Intergenerational Justice – The Rawlsian Perspective

As our concern in this chapter is to assess the desirability of the climate engineering within the Rawlsian theoretical frame of intergenerational justice, we shall first briefly discuss Rawls' perspectives on intergenerational justice. According to John Brätland (2007), John Rawls "[...] can be credited with provoking the most recent angst over the issue of intergenerational equity."[42]Lukas Meyer (2015) also thinks that to Rawls we owe "[...] the first systematic discussion of obligations to future people."[43]

Rawls' idea of intergenerational justice unfolds within the general framework of his principles of distributive justice. As we have seen in the previous chapter, the equal liberty principle and the difference principle are the two central pillars upon which Rawls builds up his theory of justice applicable to a democratic nation state. According to these principles, each person is to have an equal right to the most extensive scheme of equal basic liberties. Moreover, social and economic inequalities are to be arranged so that they are to the greatest benefit of the least advantaged in the society. The question of intergenerational equity is a natural outcome of these principles.

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[41] See Burns 2013, p. 219.
[42] John Brätland, "Rawlsian Investment Rules for 'Intergenerational Equity': Breaches of Method and Ethics," *Journal of Libertarian Studies* 21 (2007): 69-100, p. 69.
[43] Lukas Meyer, "Intergenerational Justice," *The Stanford Encyclopaedia of Philosophy* (Fall 2015 Edition), Edward N. Zalta, Ed. Available at http://plato.stanford.edu/archives/fall2015/entries/justice-intergenerational/. Accessed February 23, 2015.

Rawls addresses the issue of justice between generations in his three main works, namely, *Theory of Justice* (1971), section 44; *Political Liberalism* (1993), 274; Rawls, *Justice as Fairness*(2001), sections 49.2 and 3. It could be noted that only in his *Theory of justice* Rawls significantly dwells on the issue of justice between generations and there are only passing references to the same in *Political Liberalism* and *Justice as Fairness*. As we will see below, much of his recourse to intergenerational justice in *Political Liberalism* and *Justice as Fairness* are minor modifications or additions to his position in *Theory of Justice.*

5.3.1 Intergenerational Justice in *Theory of* Justice

Rawls takes up the issue of justice between generations in section 44 of the seventh chapter of his *Theory of Justice.* Rawls considers this topic to be very difficult subjecting an ethical theory to almost impossible tests.[44] He explores the issue of intergenerational justice in the context of setting the social minimum.[45] He thinks that the right level of social minimum cannot be set up by the average wealth of a nation or conventional expectation as they lack in precision and proper criterion.[46] He thinks that the social minimum should be decided in terms of the difference principle following a just savings principle.

> The appropriate expectation in applying the difference principle is that of the long-term prospects of the least favoured extending over future generations. Each generation must not only preserve the gains of culture and civilization, and maintain intact those just institutions that have been established, but it must also put aside in each period of time a suitable amount of real capital accumulation. This saving may take various forms from net investment in machinery and other means of production to investment in learning and education.[47]

Rawls thinks it is impossible to fix the precise measure of the just savings: "How the burden of capital accumulation and of raising the standard of civilization and culture is to be shared between generations seems to admit of no definite answer."[48] He only recommends avoiding any type of extremes in formulating the ethical constraints in fixing the rate of savings.[49]

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[44] Rawls, *Theory of Justice*, p. 251.
[45] For a discussion on the Rawlsian understanding of the idea of a social minimum, see, *Theory of Justice*, pp. 243-244.
[46] Rawls, *Theory of Justice*, pp. 251-252.
[47] Rawls, *Theory of Justice*, p. 252.
[48] Rawls, *Theory of Justice*, p. 253.
[49] Rawls, *Theory of Justice*, p. 253.

Rawls realizes that the two principles of justice (i.e., the equal liberty principle and the difference principle) will have to be subjected to some adjustment when applied to the just savings principle. For, ensuring the equal liberty of the least favoured in a given context might imply very little savings or no savings for the future generations and "[t]here is no way for later generations to help the situation of the least fortunate earlier generation."[50]This is no violation of justice as the flow of economic benefit is one directional in history. That is to say, the present generations cannot make the past generation economically better. For Rawls, justice or injustice pertains to how institutions deal with natural limitations.[51]

A just savings principle is to be adopted by making some compensating adjustments in the original position. The veil of ignorance is complete in the original position as the contracting parties do not know to which generation they belong or the economic status of their generation. However, here there is a problem that runs contrary to the motivation for savings. Since the original position takes the present time of entry interpretation,[52] the parties may find no motivation for saving for future generations, as they are contemporaries. To overcome this difficulty, Rawls makes an adjustment to the original position. He assumes the contracting parties to be representing family lines who have gained from their predecessors and are willing to save for their descendants.

> So to achieve a reasonable result, we assume first, that the parties represent family lines, say, who care at least about their more immediate descendants; and second, that the principle adopted must be such that they wish all earlier generations to have followed it. These constraints, together with the veil of ignorance, are to insure that anyone generation looks out for all.[53]

For Rawls, "[...] a savings principle is a rule that assigns an appropriate rate (or range of rates) to each level of advance, that is, a rule that determines a schedule of rates."[54] Therefore, there will be different rate of savings for different stages. And once the just institutions are established and the first principle of justice (equal liberty principle) is achieved, the savings rate falls to zero. Rawls holds that the schedule of savings cannot be fixed. However, certain motivational and ethical guidelines can be followed in piecing together this schedule. Firstly,

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[50] Rawls, *Theory of Justice*, p. 253.
[51] Rawls, *Theory of Justice*, p. 254.
[52] It means that the persons in the original position know that they are contemporaries. See, *Theory of Justice,* p. 121.
[53] Rawls, *Theory of Justice*, p. 255.
[54] Rawls, *Theory of Justice*, p. 255.

the parties should consider themselves to be fathers. Secondly, they must balance the savings for the immediate sons and grandsons against what they have inherited from the immediate fathers and forefathers. "When they arrive at the estimate that seems fair from both sides, with due allowance made for the improvement in circumstances, then the fair rate (or range of rates) for that stage is specified. Once this is done for all stages, the just savings principle is defined."[55]

5.3.2 Just Savings in *Political Liberalism*

In his second major work, *Political Liberalism*, Rawls revised his principle of just savings. The revised just savings principle is based on a revision of the original position. In *Political Liberalism,* Rawls introduces the notion of a thicker veil of ignorance.[56] The understanding of the original position in *Theory of Justice*, as we discussed it in the previous chapter, is a thinner original position where there was no rational impetus for the parties to agree on a just savings principle. In order to solve this issue, Rawls introduced the motivational assumption of the contracting parties representing family lines, whereby they care for their descendants.

In the thicker understanding of original position in *Political Liberalism*, Rawls eliminates the possibility of the parties refusing to agree on a just savings principle and replaces the familial motivational assumption with a rational motivation. In the thicker original position, the contracting parties are contemporaries, but they do not know the present state of the society and they have no knowledge of the present stock of natural resources, productive assets or the level of technology.[57]Rawls formulates the thicker original position likewise: "And so we arrive at a thicker rather than a thinner veil of ignorance: the parties are to be understood so far as possible solely as moral persons and in abstraction from contingencies. To be fair, the initial situation treats the parties symmetrically, for as moral persons they are equal: the same relevant properties qualify everyone."[58] In the thicker original position, when the parties agree on how to treat each other and the future generations, they will have to be rationally considerate to the factors of historical accident and social contingency found within the basic structure.[59] As such, there is no rational provision for the parties to evade their agreeing to a principle of just savings. Conversely, it means that all

[55] Rawls, *Theory of Justice*, p. 256.
[56] Rawls, *Political Liberalism* (New York: Columbia University Press, 1996), p. 273.
[57] Rawls, *Political Liberalism*, p. 273.
[58] Rawls, *Political Liberalism*, p. 273.
[59] Rawls, *Political Liberalism*, p. 273.

generations will have saved for the generations to come. This becomes another rational requisite of each generation to save for the following generation. That is to say, because we have received from the preceding generations, it is rationally warranted that we save for the following generations. Thus in *Political Liberalism*, the motivational assumption for just savings has been shifted from the caring principle to a rational assumption.

> The content of justice must be discovered by reason [...] since society is a system of cooperation between generations over time, a principle for savings is required. Rather than imagine a (hypothetical and nonhistorical) direct agreement between all generations, the parties can be required to agree to a savings principle subject to the further condition that they must want all previous generations to have followed it. Thus the correct principle is that which the members of any generation (and so all generations) would adopt as the one their generation is to follow and as the principle they would want preceding generations to have followed (and later generations to follow), no matter how far back (or forward) in time.[60]

Rawls holds that the revised understanding of the original position and the just savings principle removes the difficulty of the parties not being forced to agree on a rate of just savings. The condition of all preceding generations having agreed on a just savings principle had found no mention in *Theory of Justice*.[61]

5.3.3 Just Savings in *Justice as Fairness*

Rawls has reinstated his revised understanding of the just savings principle further in his *Justice as Fairness.* The difference between *Theory of Justice* and *Justice as Fairness*, in Rawls own words, is that in *Theory of Justice* it was not required of the previous generations to have followed the savings rule.[62] However, it is rationally binding on all generations in *Justice as Fairness*. In *Justice as Fairness* Rawls clarifies the conditions of the veil of ignorance necessary for the just savings principle. “Along with other conditions on the original position, the veil of ignorance removes differences in bargaining advantages, so that in this and other respects the parties are symmetrically situated. Citizens are represented solely as free and equal persons: as those who have to the minimum sufficient degree the two

[60] Rawls, *Political Liberalism,* p. 274.
[61] Rawls, *Political Liberalism,* p. 274.
[62] Rawls, *Justice as Fairness,* p. 160.

moral powers and other capacities enabling them to be normal cooperating members of society over a complete life. By situating the parties symmetrically, the original position respects the basic precept of formal equality [...]."[63] This position is a vantage point for a rational agreement on the savings rate. The contractors' agreement now is subject to the condition that all previous generations should have followed the same savings principle.

> The correct principle, then, is one the members of any generation (and so all generations) would adopt as the principle they would want preceding generations to have followed, no matter how far back in time. Since no generation knows its place among the generations, this implies that all later generations, including the present one, are to follow it. In this way we arrive at a savings principle that grounds our duties to other generations: it supports legitimate complaints against our predecessors and legitimate expectations about our successors.[64]

In *Justice as Fairness*, Rawls has also distinguished between the difference principle and the just savings principle. The difference principle holds within a generation whereas the latter holds between generations. The difference principle does not require continual economic progress over time, whereas the just savings is necessary to set the conditions to establish and preserve the just basic structure of the society.

5.3.4 Commentators on Rawls' Views on Intergenerational Justice

Lukas Meyer thinks that Rawls' original difficulty with the previous generations not having to save for the following generation was a problem of non-ideal theory.[65] Original position being an ideal theory, there can be no issue of non-compliance or partial compliance, since strict compliance with whatever principles are agreed upon is obligatory.[66]Meyer holds that it is this loophole in *Theory of Justice* that Rawls fixes in his later writings.[67]

Meyer also identifies two stages of just savings in Rawls's theory, namely, the accumulation stage and the steady state stage.[68]We have seen that in *Theory of Justice*, Rawls is not specific about the rate of savings and he thinks it is impossible to define the precise rate

[63] Rawls, *Justice as Fairness*, p. 87.
[64] Rawls, *Justice as Fairness*, p. 160.
[65] See Meyer 2015.
[66] Rawls, *Theory of Justice*, 144-45; See also Meyer 2015.
[67] See, Meyer 2015.
[68] Meyer 2015.

of such a savings. He only recommends that extremes should be avoided. Imagining themselves to be fathers, the contracting parties are to decide on the amount of savings. And the just savings rate will fall to zero when just institutions are established. Meyer calls the savings period as the accumulation stage and the stage where the rate of savings falls to zero as the steady state stage.[69]

Stephan Wolf (2010) looks at the Rawlsian intergenerational justice from the viewpoint of the difference principle and identifies a problem of intertemporality, of which Rawls himself was aware.[70]Attention to the future generations is necessary given the assumptions of the difference principle. Since the difference principle wants the resources to be allocated to the benefit of the least well off in the society in the current generation, it is likely that very little savings are possible and adequate resources are not maintained for the benefit of the future generations. For, the first generation cannot be blamed for consuming the resources in order to facilitate equal liberty for all and to make the worst-off better off. This eliminates the very scope for progress too. As Wolf (2010) has observed, from the viewpoint of a sustained progressive growth of humanity, the first generation is the worst off among all generations. This would mean that the future generations would have to transfer back resources to the earlier generations, which is physically not possible.[71] Thus the difference principle confronts the problem of intertemporality faced by any reciprocity-based theory of justice. The problem of intertemporality is that no member of the current society can enter into a co-operative scheme with the future generations. While the present generation can be influential in conditioning the well-being of the future generations, say, by reducing their options, the future generations can reciprocate nothing to the past generation acting retroactively.[72]

Wolf also holds that the just savings principle of Rawls is revealing an argumentative weakness of Rawls. Wolf (2010) opines that Rawls has been criticized much for postulating an altruistic motivation rather than a rational one.[73]Rawls switching over to altruistic motivation like caring for the descendants makes his rational grounds slippery. It is argued

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[69] See, Meyer 2015.

[70] See, Stephan Wolf, "An Intergenerational Social Contract for Common Resource Usage: A Reality-check for Harsanyi and Rawls," *The Constitutional Economics Network Working Papers, No. 02-2010* (2010). Available at http://hdl.handle.net/10419/57634: 1-21, p. 6. Accessed September 7, 2016.

[71] Wolf 2010, p. 6.

[72] A paper on intergenerational justice by FEW Resources opines that this problem with the difference principle and the absence of an intergenerational difference principle forced Rawls to make adjustments and introduce the just savings principle. See, FEW Resources 2014a. Available at http://www.fewresources.org/intergenerational-justice.html; accessed on March 20, 2016. Author not listed. Accessed October 4, 2014.

[73] Wolf 2010, p. 7.

that while the entire project of Rawls is to establish rational foundations for justice, he slips out of this ground when it comes to intergenerational justice and lands up on altruistic grounds. As Wolf puts it, "[...] he ad hoc had to assume altruism for the intergenerational case, whereas he explicitly demanded people to be self-interested in the intra-generational case."[74]It is this argumentative weakness that Rawls fixed in *Political Liberalism* and *Justice as Fairness* by revising his understanding of the original position.

5.4 Climate Engineering and Intergenerational Justice from the Rawlsian Perspective

In this section, we shall apply the Rawlsian view of intergenerational justice to assess climate engineering in the intergenerational context. Although the issue of intergenerational justice is very complex in regard to climate engineering and there are diverse models for approaching this issue, we look at it strictly from the viewpoint of Rawls. This approach is necessitated by the lead questions of this research in general and of this chapter in particular. It is true that the Rawlsian theory does not lay down specific rules of intergenerational justice for dealing with a particular issue like climate change as his theory pertains to justice at the level of the basic structure of the society. However, Rawls does provide a unique and sound theoretical frame that can inform the debate on intergenerational justice in climate engineering. We are not aiming at a critical modification of the Rawlsian theory or to assess the strengths and weaknesses of Rawls with regard to climate engineering and intergenerational justice, though certain such observations will be figuring in the outlook section in the concluding chapter of this study.[75] Here our precise focus is to see if climate engineering can meet the requirements of the Rawlsian scheme of intergenerational justice. We assume this to be an original contribution to advance the debate, as hitherto there is no systematic and detailed engagement between any specific theoretical model of intergenerational justice, let alone Rawls, and climate engineering.

As we have seen, it is characteristic of Rawls to draw his principles of justice from the thought experiment of the original position. This feature of the Rawlsian system is evidently reflected in developing the just savings principle too. Further, the just savings principle has an instrumental and procedural role as well, as it is envisaged to be facilitating the promotion of the two fundamental principles of justice in the Rawlsian scheme, namely, the equal liberty principle and the difference principle. Just savings can be dispensed with when these

[74] Wolf 2010, p. 7.
[75] See Chapter 7, 7.5.1.

principles are actualised in the society. Hence, a comprehensive application of the just savings principle - the flagship of the Rawlsian intergenerational justice –entails recourse to the hypothetical foundation and final objective of this principle, namely, the original position and the principle of equal liberty. While we will be dwelling significantly on the just savings principle, our analysis draws fruitful resources for appropriating climate engineering from the overall theoretical scheme of Rawls. This clarifies our recourse to the original position and the equal liberty principle in applying his views to a particular issue like climate engineering. That is to say, we find the general frame of the Rawlsian theory equally helpful for appropriating climate engineering along with the just savings principle of intergenerational justice.[76] We ask, what is the rational desirability of climate engineering under the veil of ignorance? Asked to choose, which of the two– mitigation or climate engineering – will the parties in the original position find better facilitate intergenerational justice? What are the implications and suggestions of the just savings principle for the issue of intergenerational justice in climate engineering?

5.4.1 Climate Engineering and the Original Position under the Veil of Ignorance

It should be stated at the outset that any intersection between Rawls and the climate engineering debate is possible if only we move some of the strict constraints of the thicker original position. In the thicker original position, the contracting parties do not know the present state of society, of the present stock of natural resources, productive assets or the level of technology.[77] We assume that for a meaningful deliberation on the principles of the contract in the context of climate change we input the most essential information regarding the dangers of climate change and the scope of climate engineering to the contracting parties.

As we discussed in chapter 4,[78] primary goods in Rawls will certainly include the environment, natural resources and healthy climatic conditions. The rational decisions in the original position should pertain to the distribution of these goods as well. The ideal original position is a vantage point for formulating just principles that are rationally justifiable. As Rawls argues, "The content of justice must be discovered by reason: that is, by solving the

[76]Similarly, Dominic Welburn, assessing the ability of the Rawlsian ideal liberal theory in addressing the environmental crises, recommends the consideration of "the totality of the Rawlsian project rather than specific sections of his work such as his 'just savings principle'." Dominic Welburn, "Rawls, the Well-Ordered Society and Intergenerational Justice," in *Politics* 33 (2013): 56-65, p. 56.
[77] Rawls, *Political Liberalism*, p. 273.
[78] See Chapter 4; 4.3.4.

agreement problem posed by the original position."[79] There is a tacit presupposition among some ethicists that in the intergenerational context, the future generations will be better off than the current generation.[80] This thinking could lead to an asymmetry of policies between generations. Hoping the future generations to be richer, the present generation may squander away more resource without feeling obliged to the future generations. It can be seen that original position does not provide room for such asymmetries. In the original position all contracting parties are contemporaries and there is no separation between present and future generations.

Let us postulate a situation where the contracting parties who are unaware of their social positions but aware of the global problem of climate change and the scope of mitigation and climate engineering at its present phase venture on deciding rational principles of justice for every generation. They consider climate as a primary good and envisage a sustainable good climate for the present and future generations. Though they are self-interested, they have no pre-conceived agenda to safeguard, as they are unaware as to which generation they would belong. What would be the strategy they would agree to? Intuition tells us that a decision under the veil of ignorance would go for the normal course of averting dangerous climate change. For, it is to be recollected that many arguments for climate engineering recommend climate engineering due to pragmatic difficulties associated with a conservative solution like changing life-style in mitigation. The veil of ignorance removes this difficulty against conservative choices. To cite Rawls again, "[...] the veil of ignorance removes differences in bargaining advantages."[81]The natural resistance of the present generation to restructuring the policies, practices and life-style in order to restore the global temperature to 2^0C from the preindustrial age will be almost absent in the original position. The force of the difficulty with the change-of-life-style argument against mitigation gets weakened as they consider the possibility that they need not necessarily belong to the current generation. The force of the economic feasibility argument in favour of climate engineering weakens as they consider the benefits of mitigation over the ages and the huge amount of money required for sustained climate engineering and its long-term impact for about 500-1000 years given the possibility that they may belong to one such future generation, and the huge amount of compensation

[79] Rawls, *Political Liberalism*, p. 274.

[80] FEW Resources 2014b. Available at http://www.amazon.com/Climate-Change-Justice-Eric-Posner/dp/0691137757. Accessed on April 28, 2015.

[81]Rawls, *Justice as Fairness*, p. 87.

they will have to set apart for those who will be harmed by climate engineering for generations to come.

Viewed from this perspective, it could be seen that much impetus for climate engineering may be drawn from the "generational selfishness"[82] of the present generation as it looks at climate change from its relative temporal position. The original position removes this constraint on the contracting parties.To substantiate our claim, let us imagine this scenario: We input the findings of a recent study on mitigation to the veil of ignorance of the parties. A study by Azar and Schneider (2002)[83] concluded that the cost of achieving a reduction in emission by 75-90% by 2100 would be 3-6% of the global GNP in this century. However, looking ahead, they estimate that even if the world has to forego temporarily a growth of otherwise 6% GNP for the sake of mitigation, still the world will be 10 times richer in 2102.Though the first finding (3-6% reduction in global GNP in this century) seems to weigh heavily against mitigation, the second finding (world being ten times richer in 2102) alleviates this negative weight. As Azar and Schneider (2002) hold: "[…] since […] global income grows by 2–3% per year, […the] abatement cost would be overtaken after a few years of income growth. Thus, the cost of 'climate insurance' amounts to 'only' a couple of years delay in achieving very impressive growth in per capita income levels."[84]

Though the fear of belonging to this generation may move some of the contracting parties to make a choice against mitigation, the chances of belonging to the next generation remove this fear. Thus the original position transcends the limits of any narrow temporal framework in assessing the mitigation. Rather than opting for an artificial solution, which is irrevocable, the parties will find it more rational to make a short-term adjustment to the existing distribution of the primary goods in order to accommodate the demands of mitigation, which will then be self-sustainable.

The overarching temporal framework of all generations present at the original position redefines the normative time scales in climate change debate. What is considered as short term in the present context may become long term and the long term may become short-term in the original position. For instance, mitigation, considered only from the point of view of the current generation is a long-term measure and climate engineering is a short-term

[82] To use Burns' phrase; Burns 2013, p. 220.
[83] Christian Azar and Stephen H. Schneider, "Are the Economic Cost of Stabilizing the Atmosphere Prohibitive? 42:1-2 (2002):73-80. See also, Burns2013, pp. 218-219.
[84] Azar and Schneider 2002, p. 77.

exercise, as claimed by the proponents of climate engineering. The weight of the differentiation between the long-term and the short-term will differ within the wider framework of the original position when applied to the entire generations. The original position thus removes the limitations of the relative advantages or disadvantages of temporal positioning of the parties in the climate change debates today.[85] Entering into the climate change debate with the present generation as the entry point poses major conceptual constraints to the debate, and proposals like climate engineering get undue mileage from such constraints. The analogy of the original position provides a more objective frame for such debates. From the original position's perspective, it appears that climate engineering, as a first option for averting dangerous climate change would find it hard to withstand the test of rational critical scrutiny.

The element of conservation emphasised by the argument from planetary obligation[86] – a main contender for intergenerational justice – is implicit in the original position. Contracting parties are likely to agree on the condition of the planet they are to inherit that in every generation it should be as good as in the original condition. Now, if they choose to geoengineer by means of SRM, the presence of the accumulating CO_2 in the atmosphere does not assure the original health of the planet in future and choosing in favour of climate engineering would not be rational.

The original position holds that parties leave to future generations at least the equivalent resources they inherited from the preceding generation. Viewed against this assumption, climate engineering does not seem to be a viable option at least for two reasons. Firstly, deploying SRM climate engineering would mean the accumulation of CO_2 in the atmosphere even though the global temperature may be temporarily lowered. In this case, the quality of planet left for future generations is not the same as the one inherited by the present generation. Secondly, some of the CDR techniques are loaded with dangerous side-effects due to increased alkalinity of the ocean. It will lead to reduction in the ocean yield. The reduced ocean yield means we do not hand over the oceans resources to the future generation in the way we have inherited them. Thus it implies a violation of the just handing over of the

[85] The current international policy debate on averting climate change is marred by the apprehensions over the relative disadvantages that these policies are likely to invoke on individual nations. For instance, nations like US, China and India were not signatories to the Kyoto Protocol for fear of its adverse impact on their economy.

[86] According to Brown Weiss, three categories of planetary obligations are very basic to intergenerational equity, namely, conservation of option, conservation of quality, and conservation of access. See Edith Brown Weiss, "What Obligation Does Our Generation Owe to the Next? An Approach to Global Environmental Responsibility: Our Rights and Obligations to Future Generations for the Environment," *American Journal of International Law* 84 (1990):190-198. See also Burns, p. 206.

resources to the future generations. It can be seen, thus, that rational choice does not permit even some of the CDR techniques like ocean acidification being considered. Further, preserving the ocean resources for future generations would imply moderate fishing. Moderate fishing is a choice against overconsumption and therefore a gesture towards changing the ways of life. Refusal to change the ways of life is the cause of the dangerous climate change that necessitates mitigation. Thus moderate fishing will be a rationally better choice than staking the quality of the ocean resources due to increased alkalinity of the ocean by some CDR techniques. Given a choice between climate engineering and mitigation in the original position, the rational parties are likely to cast their vote in favour of mitigation for fear of the uncertain world of climate engineering. Rational choices founded on human nature will have the distinct preference for a certain scenario over an uncertain one.

Further, given the inclination of the parties to avoid a generation where they may be worst off, they are likely to take a decision that is most risk-free. As the consumerist critiques of Rawls' original position have argued, under the veil of ignorance, the parties are likely to avoid as much risks as possible.[87] Behind the Rawlsian veil, the behaviour of the people could be such that they will act as "infinitely risk averse."[88]Lack of exact information will lead to a rational option for equal distribution of available positions. This principle is known as the rule of insufficient reason.[89] Using the rule of insufficient reason coupled with the standard economic assumption of risk neutrality,[90] the parties behind the veil would consent to reducing the emissions than going for a risk-prone technical fix for climate change. Revisiting the lesser evil argument from the original position, it could be argued that the contracting parties are likely to do away with a risk inviting decision by preferring to be on the safer side of mitigation. Avoiding uncertainties and risks for the future implies that the parties hold on to mitigation rather than deciding in favour of climate engineering. This means that there is no room for the lesser evil argument in the original position.

Looking at the Rawlsian intergenerational justice from the original position, Edith Brown Weiss finds a rationale for an intergenerational obligation upon every generation:

> In order to define what intergenerational equity then means, it is useful to view the human community as a partnership encompassing all generations, the

[87] Ken Binmore, "Social Contract I: Harsanyi and Rawls," The *Economic Journal* 99:395 (1989):84-102; Wolf 2010, p. 8; John E. Roemer, *Theories of Distributive Justice* (Cambridge: Harvard University Press, 1996).
[88] Wolf 2010, p. 8.
[89] Wolf 2010, p. 8.
[90] Wolf 2010, p. 8.

purpose of which is to realize and protect the well-being of every generation and to conserve the planet for the use of all generations. Although all generations are members of this partnership, no generation knows in advance when it will be living, how many members it will have, or even how many generations there will be. It is appropriate to adopt the perspective of a generation which is placed somewhere on the spectrum of time, but does not know in advance where . . . . Such a generation would want to receive the planet in at least as good condition as every other generation receives it and to be able to use it for its own benefit. This requires that each generation pass on the planet in no worse condition than received and have equitable access to its resources.[91]

5.4.2 Climate Engineering and the Principle of Equal Liberties

The Rawlsian principle of equal liberties, which we have discussed in detail in the previous chapter,[92] also provides a normative tool for appropriating intergenerational justice in climate engineering. Is climate engineering compatible with the Rawlsian principle of equal liberties? It is our contention that the freedom of the future generations is largely at stake if climate engineering, especially sulphate aerosol geoengineering (SAG), is deployed. In the Rawlsian scheme, the contracting parties in the hypothetical original position include the representatives of the future generations. The agreement that they rationally choose should uphold the freedom and liberty of all generations to come. Citizens of the generations belonging to the future are free if and only if nothing constrains their freedom in accessing the primary goods on parity. It can be seen that the freedom and liberty of the future generations will be largely conditioned by SAG at least on three counts.

Firstly, once deployed, the future generations have no choice but to carry on with SAG, failing which they will be confronted with the drastic consequences of the termination effect. Studies have shown that SAG, if deployed, will have to be carried on for five hundred to thousand years.[93] According to Vaughan and Timothy (2011): "[A] significant fraction of the effect will need to be maintained for >1,000 years, because approximately 20% of the CO_2 added to the atmosphere is only removed by natural sedimentation and weathering

[91] Edith Brown Weiss, "Climate Change, Intergenerational Equity and International Law: An Introductory Note," 15 *Climatic Change* 15 (1989): 327-335; Edith Brown Weiss, "Climate Change, Intergenerational Equity and International Law," *Vermont Journal of Environmental Law* 9 (2008): 615-627.
[92] See Chapter 4; 4.3.3.
[93] Dianne Dumanoski, Resisting the Dangerous Allure of Global Warming Technofixes, YALE ENV'T 360, Available at http://e360.yale.edu/feature/the_dangerous_allure_of_global_warming_technofixes/2224/. Accessed Nov. 21, 2015.

processes on timescales of 10,000 to 1,000,000 years."[94] And if the SAG is discontinued for technological, catastrophic, or policy reasons, a future generation is dragged into a catastrophic situation, which may even endanger their survival. Govindasamy et al. (2002) has described the consequences of a sudden termination of SAG to be "catastrophic."[95] The possibility of sudden termination cannot be ruled out for reasons of technological failure and policy decisions.[96] Studies have highlighted the dangers of sudden termination: "[S]hould the engineered system later fail for technical or policy reasons, the downside is dramatic . . . . The climate suppression has only been temporary, and the now CO_2-loaded atmosphere quickly bites back, leading to severe and rapid climate change with rates up to 20 times the current rate of warming of ≈0.2ºC per decade [...]"[97] Within thirty years of the termination of SAG, there will be a temperature increase of 6-10 degrees Celsius in the winter[98] and 7 degrees in the tropics.[99] Projected estimations of the increases in temperature will be unparalleled in history.[100] A recent study has found that an increase in temperature by 0.1 degree Celsius per decade will be highly detrimental to most major ecosystems.[101]

Here we find the future generation being deprived of the very fundamental principle of justice in Rawls, i.e., equal liberty for citizens from different generations. For Rawls, "each person is to have an equal right to the most extensive scheme of equal basic liberties compatible with a similar scheme of liberties for others."[102]Buck, Ott and Preston also have

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[94] Naomi E. Vaughan & Timothy M. Lenton, "A Review of Climate Geoengineering Proposals," *Climatic Change* 109:3 (2011): 745-790, p. 784.
[95] B. Govindasamy et al., "Impact of Geoengineering Schemes on the Terrestrial Biosphere," *Geophysical Research Letters* 29:22 (2002): 18-1, 18-3.
[96] See, Burns 2011, p. 211.
[97] Peter G. Brewer, "Evaluating a Technological Fix for Climate," *PNAS* 104:24 (2007): 9915 -9916. Available at http://www.pnas.org/content/104/24/9915.short. Accessed October 17, 2015; see also, John C. Moore, Svetlana Jevrejeva & Aslak Grinstad, "Efficacy of Geoengineering to Limit 21st Century Sea-Level Rise," *PNAS* early edition (2011). Available at http://www.pnas.org/cgi/doi/10.1073/pnas.1008153107. Accessed October 17, 2015.
[98] Brovkin et al. 2009.
[99] Eli Kintisch, "Scientists Say Continued Warming Warrants Closer Look at Drastic Fixes," *Science* 318 (2007):1054-1055.
[100] Kintisch 2007. The Increase is said to be worse than the most abrupt temperature rise in history, the Paleocene-Eocene Thermal Maximum. See also, Burns 2013, pp. 211-212.
[101] A. Vliet & R. Leemans, "Rapid Species' Response to Changes in Climate Require Stringent Climate Protection Targets," in H. J. Schellnhuber, W. Cramer, N. Nakícénovic, T. Wigley, G. Yohe, Eds., *Avoiding Dangerous Climate Change* (Cambridge : Cambridge University Press, 2006):135-143.
[102] Rawls, *Theory of Justice*, p. 53.

anticipated a type of lock-in problem[103] created particularly by SAG that might dangerously restrict future options.[104]

There is still a deeper level to the loss of freedom for future generations. Citizens pursue their conception of the good aided by primary goods. In distinguishing the primary goods into natural and social Rawls maintained that natural primary goods are not under the control of the social institutions. It is by assuming the independent existence of the primary natural goods that Rawls built up his whole system of justice. Now, with climate engineering, defined as "the *deliberate manipulation* [emphasis added] of the earth systems"[105] there arises a situation where primary natural goods are no longer freed from the control of social systems.[106] This is a not a state of affairs that can be tolerated within the Rawlsian scheme. With climate engineering social institutions within one generation are able to dictate the condition of natural primary goods of future generations, for instance, by forcing them to continue with SRM and by exposing them to the problems of sudden termination. The conditioning of the natural primary goods means that future generations are deprived not only of their freedom but also of the very fabric of freedom within the Rawlsian scheme of justice. That is to say, future generations will not only have limited freedom, but also the primary goods for facilitating their conception of the good of freedom in future will be impoverished.

Secondly, it can be reasonably argued that given the dangerous consequences of a sudden termination, SAG may not be discontinued, and conversely, sustained SAG would lead to dangerous consequences at several regions of the world, especially those regions that are economically worse off, a concern of distributive justice, which we discussed in the previous chapter. That even a single nation can develop and deploy climate engineering on its own increases the chances of the adverse and irrevocable side effects for other regions. This would deprive several future citizens off their ability to participate in the well-ordered society, a development least reconcilable with the principle of equality of freedom and liberty.

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[103] For details on the lock-in problem, see, Chapter 3, 3.3.2.2.

[104] See, H. Buck, "Climate Remediation to Address Social Development Challenges: Going Beyond Cost-benefit and Risk Approaches to Assessing Solar Radiation Management," in C. Preston, Ed., *Engineering the Climate: The Ethics of Solar Radiation Management*, 133–148; Konrad Ott, "Might Solar Radiation Management Constitute a Dilemma," in Christopher J. Preston, Ed., *Engineering the Climate: The Ethics of Solar Radiation Management* (Lanham, New York: Lexington Books, 2014): 33-42; Preston 2013. See our discussion on the lock-in problem in Chapter 3, 3.3.2.2.

[105] See Chapter 2, 2.2.

[106] The influence on primary natural good is not confined to climate engineering in particular or to climate change in general. However, the global scale and degree in which the primary natural goodsare influenced seems to be more in climate engineering.

Thirdly, if the fear of the moral hazard issue, discussed in the third chapter on literature review,[107]turns out to be realistic, it will be the future generations who will bear the brunt of this slippery slope. The deceptive conviction created by climate engineering that there is a magic bullet to avert the climate change will water down the efforts at mitigation and adaptation. The "premature conviction"[108] of the present generation gives them an easy outlet to evade their moral responsibility to change their life-styles, and if climate engineering is not as effective as expected, the whole burden of the compounded dangers is placed on future generations. The moral hazard issue too thus sets serious limits to the freedom and liberty of the future generations.

It is clear from various studies that future generations could be exposed to serious potential harms resulting from climate engineering.[109] If the present generation takes recourse to climate engineering to cling on to its ways of living, it could be inflicting serious harms to the future generations. It means undue advantage for one generation at the cost of justice to future generations. This is not an outcome that can be accommodated in the ideal theory of the original position. In the Rawlsian scheme, all contracting generations should rationally agree on principles that everybody has equal access to the primary goods of the society. In dialoguing between climate engineering and Rawls, it can be seen that the issues of responsibility abdication, lock-in problem, passing the buck, etc., have no place in the Rawlsian scheme of intergenerational justice and any chances of such loopholes is a matter of non-ideal theory. As Rawls puts it: "[...] persons in different generations have duties and obligations to one another just as contemporaries do. The present generation cannot do as it pleases but is bound by the principles that would be chosen in the original position to define justice between persons at different moments of time. In addition, men have a natural duty to uphold and to further just institutions [...]."[110]

Accordingly, there is very little desirability for climate engineering in its present manner within the ambit of the Rawlsian intergenerational justice. Svoboda et al. (2011) also confirm our conclusion: "Further, Rawlsian intergenerational justice also requires that any socio-economic inequality among future persons benefit all future persons (including the

[107] See Chapter 3, 3.3.2.6.
[108] Phrase is of Royal Society 2009, p. 276.
[109] See Chapter 3, 3.3.2.1.1.
[110] Rawls, *Theory of Justice*, p. 258.

worst off), but discontinuous SAG could cause economic damages for future persons that increase socio-economic inequality without benefiting all."[111]

5.4.3 The Just Savings Principle and Climate Engineering

5.4.3.1 The Primacy of the Primary Good of Environment

The context of climate change gives a deeper nuance to the concept of just savings in Rawls. Although Rawls did not think of just savings in an ecological setting, the notion becomes more foundational and substantive in this context. While Rawls recommended just savings as a means to the establishment of just institutions, in the context of climate change, saving the climate becomes foundational, as environment is a primary natural good. In the climatic context, it appears so that one of the basic structures of the society itself needs to be saved for prospect of every other basic structure in future. Primary goods in Rawls like opportunity, money, knowledge, skills, etc., are meaningful only in a healthy environmental context. As for the human body, the natural good of health has primacy over other social goods like shelter and clothing. So too, for justice, saving the environment for future is more primary than saving material resources, forming consensus on a saving rate, or creating a contingency fund for establishing just basic structures. It is a primary saving which will be justified by altruistic as well as rational norms.

In the setting of climate change, the contracting parties in the original position are likely to discuss the content and object of saving prior to the rate of saving. In the climatic context, holding a rational discussion under the veil of ignorance exclusively on the saving rate in order to facilitate the establishment of just institutions in future, overlooking the dangers of climate change, seems irrational. The primary content of the savings will be the environment itself.

Once the primacy of the primary good of environment is acknowledged by the parties, a natural rational decision for the environment or a saving meant for the environment will be towards the sustained maintenance of quality environment rather than saving for a technical fix to the environment, which is a temporary solution. Now, saving the primary structure of the environment means safeguarding oceans, forests and glaciers, and cultivable land. Therefore, acknowledging the primacy of the primary good of environment is likely to lead the parties to a radical consensus that will avoid any dangerous climate change in future that will have to invoke mitigation, or, let alone climate engineering. However, given the present-

[111] Svoboda et al. 2011, p. 23.

time entry interpretation of the original position, if at all the contracting parties have to agree on a saving rate for avoiding dangerous climate change, it is likely to be towards sustained mechanisms for saving the climate than for any temporal technical fix, for in an ideal state of mind detached from hidden motives, as in the original position, human nature does not confuse between the perennial and the temporal.

Now, does climate engineering have the potential to save the primary good of environment for the establishment of just institutions in society? If climate engineering were a full-proof technique for averting dangerous climate change we could have treated it as the best contribution of this generation to the future fulfilling the criterion of the Rawlsian just savings. However, the perceived side-effects, potential risks and speculated harms[112] associated with this technology do not entitle climate engineering as a legitimate candidate for this title. As per the available scientific estimations, climate engineering has several adverse side-effects whereby the above mentioned ecological values will be compromised in future. Rational choices demand that parties in the original position who are keen to ensure justice to all generations out of fear of belonging to an unlucky generation will allocate the resources such a way that they avoid the conditions that would cause the loss of the natural primary good of healthy environment rather than first risking the health of the environment and then following it up with a dubious technical solution. In other words, the just savings principle in the original position will address the root cause of dangerous climate change rather than treating its consequences. This takes us to the point of major contention between the proponents and opponents of climate engineering, as discussed in the third chapter,[113] that climate engineering treats the symptoms of climate change rather than the root cause. The Rawlsian just savings principle has an implicit preference for treating the root cause over the symptoms. Therefore, a rational just savings decision would favour savings for maintaining the conditions of a healthy environment – the strategy of mitigation –rather than saving for the research and development of climate engineering technologies.

This observation does suggest something about the present-day debate on mitigation as well. Favouring a saving for maintaining the conditions of a healthy environment for future generations is the implicit motivational assumption behind the present strategies coined in the context of climate change, like the carbon fund, the contingency fund, compensation by the developed nations to the developing and underdeveloped nations based on differentiated

[112] See Chapter 3, 3.3.2.7.
[113] See Chapter 3, 3.3.2.8.

responsibility, funding for developing renewable energy resources and reducing fossil fuel consumption, as reflected in the Kyoto and the Paris agreement. The agenda of reducing the consumption of non-renewable energy sources, say for instance, crude oil, has the double advantage of saving such resources for future generations as well as saving the conditions for a healthy environment for future generation. Thus, the just savings principle of Rawls is tacitly subsumed in many of the present mitigation strategies evolving from international climate change summits.

Now, the professed claim of the hard-core advocates of climate engineering is that the economic feasibility of climate engineering can save the nations from the challenging constraints of the demands of mitigation. But on a critical scrutiny it could be argued that while it promises to avoid the constraints of mitigation, it offers no real solution to the dangers of climate change. Climate engineering deceptively claims that the present generation can do away with the obligations to the future generations, or in the Rawlsian terms, it can evade the just savings at least in the context of climate change. In the Rawlsian theoretical frame of intergenerational justice, climate engineering is not only incompatible with the just savings principle, but it also runs contrary to the aspects of the just savings currently exercised in the society. Therefore, in the Rawlsian scheme of intergenerational justice, there is little rational force for climate engineering to be a choice for the contracting parties to comply with the just savings principle.

5.4.3.2 Weighing the Family Line Argument

It is our contention that the family line argument of just savings in *Theory of Justice* has the potential for redressing the root cause of dangerous climate change and as such it will partly eliminate the need for climate engineering by removing some of the conceptual difficulties with mitigation. Rawls had modified his original idea of the just savings principle to make it rationally more credible by removing its altruistic motivation. However, the scientific wisdom of five decades since the *Theory of Justice* seems to inform something otherwise. An altruistic principle gets better rational respectability in the scientific worldview today. In the Rawlsian understanding of rationality in the original position, the parties are self-interested and mutually disinterested. This idea of rationality that Rawls assumes in his theory seems to be old fashioned, as it does not absorb the imposing tenets of the anthropology emerging from the latest scientific findings, especially in neuroscience.[114] Organisms are structured as to care for the other. The organic and biological continuity of species is also based on principles of "altruism." Contemporary biological and neurological sciences speak of the genes of altruism.[115]Thus the Rawlsian motivation as caring for the descendants is not without its rational support. Today altruism appears to be a sound biological and anthropological factor. Therefore, the mutual disinterest among parties postulated by Rawls so as to make his theory ideally rational does not seem all that necessary. Probably, the present scientific anthropology provides a better framework for fixing this apparent argumentative weakness in Rawls. This justifies us in using the original motivational assumption of care for just savings in our assessment of the desirability of climate engineering.[116]

These observations give us a direct allusion to the care ethics. The new anthropological dimensions outlined above are considered by Christ Gastmans as essential for care ethics: "Ethics of care stands for a unique normative perspective from which human behavior can be interpreted and evaluated. In order to have normative power, ... care ethics needs an explicit anthropological basis – a view of mankind that underlies care. This explicit anthropological basis helps us to clarify concepts closely related to care ethics such as vulnerability, interdependence, care, responsibility, relational autonomy, dignity, personhood."[117] Gastmans thinks that relational and contextual embeddedness of the ethical issues is the central factor in care ethics.[118] Tronto gives four dimensions of care, namely, the attitude of caring about, taking care, care giving and care receiving. Caring about refers to the concern for the conditions of a suffering fellow human and taking care means assuming the

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[114] See, V. S. Ramachandran, *The Tell Tale Brain* - A Neuroscientist's Quest for What Makes Us Human (New York: W. W. Norton and Company, 2011).

[115] See, Ashleigh S. Griffin et al., "Cooperation and Competition in Pathogenic Bacteria," *Nature* 430 (2004): 1024-1027; Dominik Refardt, "Altruism can Evolve when Relatedness is Low: Evidence from Bacteria Committing Suicide upon Phage Infection," Proceedings of the Royal Society B. Published 20 March 2013. Available at http://rspb.royalsocietypublishing.org/content/280/1759/20123035.short. Accessed on January 8, 2016; W. D. Hamilton, "The Evolution of Altruistic Behavior," *The American Naturalist* 97:896 (1963): 354-356; Herbert Gintis, "The Hitchhiker's Guide to Altruism: Gene-culture Coevolution, and the Internalization of Norms," *Journal of Theoretical Biology* 220:4 (2003): 407-418; J. Maynard Smith, "Models of the Evolution of Altruism," *Theoretical Population Biology* 18 (1980):151-159.

[116] As stated earlier, we are not aiming at modifying or hermeneutically adapting Rawlsian just savings principle so as to suit our discussion. Rather these observations are only some off-the-cuff remarks to justify our recourse to the early version of the just savings principle. We are aware that even this claimed rational ground of altruism is no sufficient argument to bind the contracting parties to agree to save for future generations.

[117] Interview with Chris Gastmans on April 8, 2011. Available at https://ethicsofcare.org/chris-gastmans/. See also, Chris Gastmans, "The Care Perspectives in Healthcare Ethics," in Anne J. Davis, Verena Tschudin, & Louise de Raeve, (eds.), *Essentials of Teaching and Learning in Nursing Ethics: Perspectives and Methods* (New York: Churchill Livingstone Elsevier, 2006): 135-148.

[118] See, Gastmans 2006.

responsibility to provide care. Care giving requires necessary competence and attentiveness. Care receiving is the responsiveness of the care receiver to the care giver.[119] Gastmans holds that care as a virtue must be distinguished from emotional involvement. For care involves cognitive, affective and motivational components.[120]

Does the revised understanding of care as a rational motivation for just savings suggest anything to the debate between mitigation and climate engineering? We think, in the ecological context, the motivation of care does serve a double purpose. Firstly, the parties decide to preserve the natural resources for their immediate descendants out of their caring attitude for their immediate descendants. Secondly, there is an added impetus for preserving the natural resources in this perspective. That is to say, as the old Darwinian model of the tree of life is getting replaced by the new metaphor of the web of life – a metaphor which speaks of the interconnectedness of living beingsand the biological continuity of species - each organism in particular and nature in general are intrinsically entitled to care and protection. This takes us to another major argument in the climate engineering context, which is the deep ecology argument. As we have seen in chapter three, deep ecology holds that ecological crisis is a consequence of our overconsumption and failure to care for nature. It means that the current generation, in the Rawlsian terms has not been caring enough. Many ecological writers have stated that the masculine value system empowered by machine and materialistic attitude towards nature is responsible for the ecological disasters.[121]In the Rawlsian perspective, the fatherly motivation is concerned only with the welfare of the future humanity. However, as we have argued above, the emerging tenets of an evolutionary view of life with its emphasis on altruism, harmony and the human relatedness to the rest of the species would expand the range of "caring" to the non-humans and to nature in general. The Rawlsian perspective of the just savings in its original version of the parties representing family lines has the potential to address the root cause of the ecological crisis. Since climate engineering is often treated as a technical fix, treating the symptom over the root cause, the caring motivation will conversely rule out the need for climate engineering. Therefore, from the Rawlsian perspective of the just savings in its original conception, there is no choice

[119] J. Tronto, *Moral Boundaries - A Political Argument for an Ethics of Care* (New York: Routledge, 1993).
[120] See, Gastmans 2006, pp. 138-139. For further reading in care ethics, see, H. Kuhse, *Nurses, Women and Ethics* (Oxford: Blackwell, 1997); T. Kohn and R. Mckechnie, (eds.), *Extending the Boundaries of Care: Medical Ethics and Caring Practices* (Oxford, New York: Berg, 1999).
[121] See for instance, L. Robert Keck, "The Next Step in Humanity's Evolutionary Journey – The Prodigal Comes Home," in *Journal of Dharma* 18:3 (1993): 211-217.

between mitigation and climate engineering; rather, the chances of creating dangerous climatic conditions that warrant climate engineering are eliminated.

5.4.3.3 Interrupting the Progressive Ascent of Justice

As we have discussed above, a major force of the just savings principle revised by Rawls in his later writings[122]is that the parties ought to save for their descendants because their predecessors had saved it for them. Thus just savings is meant to serve the final goal of justice, that is, the establishment of just institutions. Refusal to comply with mitigation, viewed from the perspective of the Rawlsian just savings principle, raises questions on the moral identity of the present generation. Each generation, in the Rawlsian scheme, is envisaged to be both as a recipient as well as a giver. The goal of economic and social development as the establishment of justice is to be seen as a continuous, cumulative and dynamic process in which all generations are responsible partakers. Any generation refusing to assume its responsibility would obstruct the progressive ascent of social and economic benefits and thereby interrupt the continuum of justice marching towards the establishment of just institutions. Such an obstruction to the normal course of the continuum of justice is irreconcilable with what Rawls holds as "[...] natural duty to uphold and to further just institutions [...]."[123]Any lethargy inflicted to the progressive movement of justice cannot uphold the ideal of intergenerational justice of viewing "[...] human community as a partnership encompassing all generations [...]."[124]Refusal to mitigate or an option for a technical fix will earmark the present generation as ungrateful receivers or as selfish takers, instead of being responsible givers. Refusing to take the conservative position of changing life-styles would mean that with the current generation, the flow of justice as a dynamic and ongoing continuum is broken. Thus the just savings principle, literally as a principle of savings, is opposed to overconsumption, which is said to be the root cause of the climatic change.

Rawls always looks at the just savings principle within a historical continuum. This is a principle, which all preceding generations will have followed and the following generations will be following. To cite Rawls again, "The correct principle, then, is one the members of any generation (and so all generations) would adopt as the principle they would want preceding generations to have followed, no matter how far back in time. Since no generation knows its place among the generations, this implies that all later generations, including the

[122] See internal references,
[123] Rawls, *Theory of Justice*, p. 258.
[124] Weiss 1989, p. 330.

present one, are to follow it."[125] Assessing climate change historically, we find the epithet 'anthropogenic' itself as suggestive of a deviation from the ideal values of the just savings in our present phase of evolution. It is a more or less accepted view that the exponential economic progress beginning with industrial revolution has led to excessive consumption of natural resources against the moderate use of the same in the pre-industrial age. The excessive patterns of consumption resulted in many developed nations overshooting their eco-footprint and bio-capacity. In the Rawlsian terms, without subscribing to the extremities of ecological fundamentalism, we could legitimately observe that the present generation significantly deviated from the correct principle that was faithfully followed by the preceding generations. Resorting to climate engineering as a rectification to our historical deviation, even if it is successfully developed and employed, does not seem to restore the historical continuity of the correct path of development based on the revised just savings principle.

Applying the Rawlsian just savings principle to the climate engineering debate, we find that the arguments of the opponents of climate engineering like "responsibility abdication" and "passing the buck" get greater rational and ethical plausibility from the point of view of intergenerational justice. It shows that in an ideal theory of intergenerational justice, the theory rectified by Rawls with his thick veil of ignorance, a justification for climate engineering and any preference for climate engineering over mitigation becomes very much dubious.

5.4.3.4 Steady State Stage ever Attainable?

In Rawls, what commands the present generation's obligations to future generations is defined as, "the conditions needed to establish and to preserve a just basic structure over time."[126]The just savings principle is one of such conditions to preserve a just basic structure over time. Rawls holds that just savings can be discontinued once just institutions are established and the generations only need to maintain the just basic structure at this steady state stage. It is clear that the current generation is still at the accumulation stage. The looming threat of dangerous climate change shows that the fate of the present generation is far from being safe and steady. If the just institution of a sustainable climate were already established there would have been no need for a debate on climate change and climate engineering. Applying the just savings principle to the climate engineering debate, it is a matter of contention whether steady state stage is ever attainable. There are at least two future

[125] Rawls, *Justice as Fairness*, p. 160.
[126] Rawls, *Justice as Fairness*, p. 159.

scenarios emerging from the deployment of SRM climate engineering that makes the steady state stage ever unreachable. Firstly, if SRM is deployed, future generations will have to keep on deploying this technology for a very long period for fear of the consequence of sudden termination. As long as the primary natural good of a sustainable environment remains technology-dependent, it cannot be claimed that just institutions are established, because the proposed technology as of now is prone to several risks. Secondly, for hypothetical reasons, even if we concede to the argument that SRM can be terminated at a certain stage in the long-term future, still there is the problem of the impoverishment of the worst off as a result of the deployment of SRM for a long period. This issue of distributive justice will have to be tackled from the perspective of the difference principle in Rawls. Having to invoke the difference principle in the future and having to allocate a significant amount of natural resources for the welfare of the least well-off in the society in the future, minimises the scope for future societies to reach a steady state stage, or to the minimum, it significantly delays the steady state stage. In either case, SRM climate engineering does not seem to be compatible with the ultimate objectives of the just savings principle for intergenerational justice.

The revised version of the just savings principle implied that there is transfer of resources from generation to generation. People should leave their descendants at least the equivalent of what they received from the preceding generation. Will the parties in the original position decide to use freely the natural resources handed over to them and develop the technological resource of climate engineering to be handed over to the future generation in order to balance the resources they consumed? Now it could be examined, in the setting of climate change, which one is more suited to achieving the steady state, whether natural resources at the sustainable level or the climate engineering technique as a technical resource to be counted as the resource to be transferred to the future generations. If the contracting parties were to make a rational choice in this regard, it appears as a straightforward option that they would go for natural resources as they are more primary, whereas climate engineering technique can be developed any time in future especially given the chances of the availability of more advanced technology as society makes progress over time. And if they decide to develop a technology to be transferred to the future generations, there is the more proximate scope for developing state of the art technologies for tapping renewable energies. Developing renewable energy is a step towards mitigation. Further, if they irrationally consider climate engineering technology as the resource to be handed over to the future generations, it appears that such a choice would violate yet another aspect of the just savings principle, i.e., the preservation of quality: "Each generation must not only preserve the gains of culture and civilization, and *maintain intact* (emphasis added) those just institutions that have been established [...]."[127]Having to switch over to climate engineering implies that the quality of the institution of nature is not intact. That is to say, if the contracting parties decide to save for climate engineering without curtailing emissions, there will be significant increase of the CO_2 in the atmosphere and the quality of the climate they hand over to the next generation will be significantly impoverished.

It appears that almost every aspect of the Rawlsian view on intergenerational justice underscores the primacy of mitigation strategies over a technical fix. So climate engineering cannot be considered as a first option in combating climate change.

5.4.4 Climate Engineering Compatible with Intergenerational Justice?

It might be argued by the proponents that the Rawlsian system can be compatible with intergenerational justice. Here we try to respond to some of such possible argumentsfrom a general point of view as well as the from the Rawlsian point of view of just savings.

It could be asked whether SRM is compatible with intergenerational equity. Would a proper governance mechanism make it more compatible with intergenerational equity? We must answer in the negative. It can be seen that as of now there is no proper governance mechanism over SRM that can ensure that it will be deployed with due regard to intergenerational justice.[128] Burns (2013) highlights the limits of UNFCCC in governing SRM.[129] Burns (2011) looks at the existing treaties related to the environment such as UNFCCC, ENMOD, and CBD. None of these treaties are found to be adequate to exercise governance over climate engineering techniques in a comprehensive manner. Even if there was authority under UNFCCC, the absence of political will does not assure the exercise of such a mandate. After all, the motive for climate engineering comes from a failure to achieve adequate mitigation.[130] Although SRM would come under the ENMMOD, the clause on 'peaceful purpose' may be used as legitimising the exercise of SRM. Further, it is a treaty with a limited number of subscriptions. Although CBD is already invoked in climate engineering experiments (CDR), its resolutions are not legally binding on the parties.[131] The

[127] Rawls, *Theory of Justice*, p. 251.
[128] See Burns 2013, p. 213.
[129] See Burns 2013, pp. 213-214.
[130] Burns 2013, p. 215.
[131] Burns 2013, p. 217.

limitations of these legal frameworks show that the chances of SRM being deployed without ensuring intergenerational justice are high.

Svoboda et al. consider SRM to be incompatible with intergenerational justice given the chances of uneven distribution of harms and benefits of SRM for future generations.[132] Svoboda et al. (2011) use the theoretical models of intergenerational justice in Rawls (1999), Dworkin (1981), Wigley (2006) and Sen (1982) and conclude that SRM "would increase the harms suffered and decrease the benefits enjoyed by some future persons."[133] Thus even if future generations were to be richer because of SRM, still there would be "socio-economic inequality between particular future persons."[134]

It may possibly be argued by some proponents that SRM helps restoring the just basic structure. SRM will bring the climate to a steady state stage, which only needs to be maintained. This argument deserves some respect as it holds legitimacy in the precise context of the earth having crossed the tipping points and all our genuine efforts at mitigation are proven to be inadequate to avert the imminent catastrophes. Then probably, climate engineering, coupled with mitigation, becomes desirable from the Rawlsian perspective as a resource to be developed and handed over to future generations. Here future generations are enabled to deploy climate engineering in order to tackle the problem of climate catastrophe. In the Rawlsian scheme, this scenario may fall under the wider spectrum of the elements of just savings covering infrastructure, knowledge and skills.

However, this argument cannot be stretched out disproportionately in favour of climate engineering. Will SRM enable us to handover a basic structure to the future that they only need to maintain? We should answer in the negative. Even in the scenario mentioned above, climate engineering does not assure future generations that they only need to maintain the climate attained by climate engineering. For, the climate restored by climate engineering is far from being steady. After all, as long as there is CO_2 accumulation in the atmosphere, there can be no climatic steady state. If the promotion of the just basic structure is the norm for intergenerational justice, as of now it seems that mitigation is the right strategy.

Secondly, it could be argued that in Rawls, the just savings principle refers not only to material resources, but also to infrastructure, knowledge, skills, etc. Therefore, research and development of climate engineering may be treated as a step towards promoting just

[132] Svoboda et al. p. 23.
[133] Svoboda et al. p. 23.
[134] Svoboda, p. 23.

institutions. This argument seems to be in consonance with the spirit of the just savings principle. However, this argument is not freed from the arguments against research and development raised by several opponents.[135] As Gardiner (2007) has rightly observed, in terms of knowledge there may be better technologies, say green energy solutions, which could be developed with the funding used for climate engineering research.[136]For instance, suppose the parties in the original position were to be given the finding by McKinsey and Associates and Vattenfall Institute in 2010 that if we make massive efforts at developing technologies for renewable energy and for enhancing energy efficiency, twenty seven gigatons of annual potential carbon dioxide can be abated at a cost of $40 per ton that would suffice to stabilize the atmospheric concentrations at 450-550 ppmv.[137]The parties, given the choice for developing climate engineering technologies or alternative energy technologies, would likely invest in the latter. So, if given a choice between mitigation and climate engineering, it seems mitigation provides better knowledge conditions to establish and preserve just basic structures over time. The risk-proneness and the open-ended uncertainties associated with this technology do not qualify it to be reliable and firm knowledge. Owing to the risk aversive behaviour of the contracting parties in original position, they would prefer to go for research and development of green technologies.

Thirdly, one might argue that we can attain the target of achieving the temperature of 2^0C prior to the industrial age through climate engineering and it helps us leave the earth to the future in the manner we have received, which would imply compliance with Rawls' just savings principle. It should be noted that from the previous generation we have received the total earth and not just earth's temperature in isolation. Leaving the earth in its ecological wholeness to the future generations and leaving an artificially cooled earth are different. To quote Keith et al. (2010) again, "it is vital to remember that a world cooled by managing sunlight will not be the same as one cooled by lowering emissions."[138] It is our position that cooling the earth through climate engineering and handing it over to the next generation do not meet the objective of just savings, for two reasons. Firstly, the possibility of an artificial technical fix, given the looming scientific uncertainties around it, is not likely to invite serious attention of the contracting parties in original position. Secondly, the sustained

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[135] See Chapter 3, 3.3.2.2.
[136] See Gardiner 2007.
[137] Eric Beinhocker et al., "The Carbon Productivity Challenge: Curbing Climate Change and Sustaining Economic Growth," McKinsey Global Institute (June2008). Available at http://www.mckinsey.com/mgi/publications/Carbon_Productivity/index.asp. Accessed January 9, 2015.
[138] Keith et al. 2010, p. 426.

technical intervention reduces the chances of the society reaching at a steady-state stage. Parties in the original position would not consider climate engineering as a natural means "to uphold and to further just institutions"[139] for from the perspective of original position, the anthropogenic climate change itself is a problem, in the Rawlsian terms, of non-ideal theory. That is to say, dangerous climate change is the result of non-compliance of present or preceding generations with the ideal decisions of the original position. The dangerous climate change occurs because parties in the original position did not formulate the ideal principles with which they should have been shaping their social interactions. Now envisaging future is to go for the ideal way that is formulation of the ideal principles and compliance with the ideal terms of the original position. Technical fix in this context is an artificial means that is likely to fall outside the purview of the original position. Therefore, from the point of view of original position, the preferred means to the restoration of the global temperature to a pre-industrial state is strict compliance with the rational terms of the original contract.

In conclusion, though some of the elements of the Rawlsian view of intergenerational justice seem to deceptively support climate engineering, on critical scrutiny such arguments can be found to be not favouring climate engineering.

5.5 Recommendations

Our analysis of the principles of intergenerational justice from the Rawlsian perspective has shown that climate engineering poses serious challenges. Highlighting those challenges was not meant to show that climate engineering should be ruled out altogether. Rather, awareness of those challenges should enable policy makers to approach the topic with due caution and to prepare in advance with maximum homework done if climate engineering becomes a policy option in future. Accordingly, in tune with our dialogue between Rawls and intergenerational justice in climate engineering, we shall make five recommendations for the future course of debate in climate engineering.

Recommendation1. The encounter between climate engineering and Rawls has underscored the futility of climate engineering as a Plan A or the best option argument.[140] It was found that many hard-core exponents of climate engineering present climate engineering as the first option in combating climate change. It becomes clear that such extreme views do not find favour with an intergenerational scrutiny and they could be founded only on untested scientific assumptions, biased philosophical premises, skewed ethical perspectives or even

[139] Rawls, *Theory of Justice*, p. 257.
[140] See Chapter 3, 3.4.2.2.

discard of intergenerational concerns. Our analysis in the preceding section has shown that the Rawlsian view of intergenerational justice does not endorse the primacy of climate engineering over mitigation. If climate engineering is to be resorted to in combating climate change, it could be only as a complimentary tool to mitigation and not a substitute for mitigation. Better for the climate engineering debate to do away with its megalomaniac promises and hubristic rhetoric and begin to engage the issue on more realistic terms. Giving away such rhetoric has the pragmatic benefit of eroding the moral hazard challenge. Rather, a reverse logic could use the helpless choice of having to resort to a “last resort”[141] option like climate engineering as a means to aggravate the efforts at mitigation. Thus the clear identification of the status of climate engineering in the overall efforts at combating climate change has the benefit of turning the tables on the dangers of moral hazard in climate engineering.

Once the status of climate engineering is positioned as supplementary to mitigation, being fair to the future generations necessitates affirming the political will for mitigation. The political will to mitigation in curbing the emissions in the present generation could be a yardstick to measure as to how much political willingness does exist to safeguard the interests of the future generations. As of now the picture is very oblique as the contemplation of climate engineering itself is due to the lack of political determination at curbing the emissions.[142] There are reliable predictions that carbon emissions may go up 43% by 2035 from the levels in 2007.[143] The reluctance of the present generation at reduction even in the face of such looming immediate threats does not leave us optimistic as to the assurance of justice to the future generations. Therefore, any serious deliberation on climate engineering should ensure a tangible treaty reflecting a determined political will to curb the emissions. Probably, the signing of the historic Paris agreement on the Earth Day on April 22, 2016 by 175 nations is a small step towards this direction.

Recommendation 2. We have observed on a couple of times in the preceding chapters that the climate engineering debate is heavily skewed towards SRM schemes.[144]This skewed focus on SRM implies more potential harms for future generations. In the choice between SRM and CDR techniques against the interest of the future generations, the CDR techniques will certainly enjoy the upper hand. The CDR approaches seem to be relatively less

[141] See Chapter 3, 3.4.2.1.
[142] See, Burns 2013, p. 215.
[143] US Energy Information Administration, International Energy Outlook 2010 – Highlights. Available at http://www.eia.doe.gov/oiaf/ieo/highlights.html. Accessed August 23, 2014.
[144] See for example Chapter 3, 3.4.2.3.

challenging to the interests of the future generations, particularly as it involves no termination issue. Hence the future course of the debate should seriously consider the recommendations made by Royal Society and IPCC to rely on CDR techniques to begin with.

Recommendation 3. The range of governance mechanism in climate engineering should necessarily include the intergenerational concerns. The proposed models of governance[145] do not dwell significantly on the intergenerational issues. Policy decisions formed by a well established governance mechanism may be able to regulate climate engineering curbing any chances of complaints like passing the buck, responsibility abdication, lock-in problem, and get-out-of-jail-free card. For instance, as Burns (2013) has observed, conditioning the deployment of SRM scheme on a scheduled reduction in greenhouse gas emissions of sufficient magnitude can thwart the termination effect for future generations.[146] Governance authorities, especially democratic ones, often have the tendency to yield to the pressures of the immediate problems and proximate population. Unprecedented levels of systematic farsightedness and commitment to the needs of the future will have to be anticipated in any governance mechanism in climate engineering, as though the governance body consists of representatives of all generations, as in the Rawlsian hypothetical original position.

Recommendation 4. Another recommendation in the governance aspect in ensuring intergenerational justice is to make necessary amendments to the existing international treaties and laws relevant to climate change. Climate engineering being a relatively new candidate on the climate change forums, none of the existing international treaties or laws directly covers climate engineering. Nonetheless, treaties like UNFCCC, ENMOD and CBD seem to be the obvious references for climate engineering.[147] Article 3 of the UNFCCC refers to intergenerational justice: “The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity [. . .].”[148] However, the objectives of these treaties do not extend to the full range of climate engineering schemes. As Burns (2013) has observed, UNFCCC is the only treaty that includes intergenerational equity considerations in non-preambular provisions.[149] Therefore, treaty amendments with necessary

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[145] See Chapter 3, 3.4.2.7.
[146] Burns 2013, p. 213.
[147] For a detailed discussion on the international legal frames relevant to geoengineering, see, Albert C. Lin “International Legal Regimes and Principles Relevant to Geoengineering.” William C. G. Burns and Andrew Strauss, Eds., *Geoengineering the Climate: Law, Ethics and Policy Considerations* (Cambridge: Cambridge University Press, 2013): 182-199.
[148] UNFCC, U.N. Doc. A/AC.237/18 (May 9, 1992), reprinted in 31 I.L.M. 849 (1992).
[149] See Burns 2013, p. 207.

force to intergenerational justice is a mechanism to be in place for climate engineering schemes to take off, especially with the participation of the profit-driven private stakeholders in the climate engineering research proposals. Given the universal and intergenerational impact of climate engineering, treaties should elicit as much consensus on climate engineering schemes. Single-nation deployment is a feasibility consideration for the proponents. This feasibility does not augment well with the rights of the future generations and will have to be pruned by necessary terms.

Recommendation 5. The issue of compensation will have to be revisited from the perspective of the Rawlsian intergenerational views. The present international compensatory mechanisms like carbon fund targeting those harmed by mitigation in the present generation cannot be paradigmatic in the context of climate engineering as the adverse side effects of climate engineering become active in future. Where we cannot anticipate the full consequences of the climate engineering for future generations, more than compensation what is warranted is perhaps a deliberate saving mechanism for future, which may partly alleviate the dangers of unforeseen side-effects. The Rawlsian emphasis that the difference principle should be operational subject to the just savings principle carries clear message to the current deliberations on compensation issues in climate change policies. It calls for pruning our consumption and saving for future even against the odds of resources being insufficient for the current generation. It is likely that the compensatory demands on individual nations will be more rigorous in the context of climate engineering than in mitigation. The recent Paris agreement being criticised by some of the developed countries as skewed unduly to the benefit of the developing populations like India and Brazil show that individual nations, even affluent ones, would find it hard to transcend the subjective interests in handling an international and intergenerational problem. International approval of any climate engineering proposal without clear clarity on the rate of saving, the rate of compensation, the beneficiaries of compensation and saving, the duration of compensation and saving, etc., is not advisable, though currently these all may remain much at the speculative level. Further, the cost analysis methods of climate engineering need to be amended as to include some provision for addressing compensations and savings for future generations in some manner. The present claim on the economic feasibility of climate engineering has little attention paid to the potential harms to future generations.

5.6 Conclusion

Our concern in this chapter was to assess the desirability of climate engineering from the perspective of the Rawlsian idea of intergenerational justice and to outline the conditions, which any climate engineering project may have to incorporate from the same point of view. Accordingly, in the first part we saw the various dynamisms of the debate on intergenerational justice in the climate engineering context. In the second part, we presented the Rawlsian view of intergenerational justice especially focusing on the just savings principle. In the third part we evaluated the climate engineering proposal against the Rawlsian principles of original position, equal liberty and just savings. Although, in this part, the odds are shown to be much against climate engineering, in the fourth part, we made some recommendations that are helpful to make climate engineering somewhat comply with the demands of intergenerational justice. It is acknowledged that we did not dwell on a specific form of the climate engineering technology to assess its compatibility with the Rawlsian scheme.

Our study suggests that intergenerational concerns from the justice point of view pose a significant challenge to climate engineering. The analysis from the Rawlsian point of view shows that the almost exclusive focus on the termination effect as the biggest challenge to intergenerational justice is much arbitrary ignoring the issues that are equally or perhaps more important in this context. Further, the analysis shows that it is legitimate to be sceptical towards the claims of the proponents about climate engineering as the best option in combating climate change. Based on the analysis we are inclined to concur with Burns that "The potential intergenerational consequences of climate engineering counsel strongly in favor of doubling our resolve to address an issue for which this generation is profoundly responsible."[150] The self-criticism and introspection of the present generation, as vividly demonstrated in the writings of a number of climate engineering authors who caution the present generation not to evade its responsibility is a testimony to the critical advancement that the debate has made.

[150]Burns 2011, p. 220.

The aim of our research is to see if climate engineering can be developed in a just manner compatible with the Rawlsian principles of distributive, intergenerational and procedural justice. So far we have addressed the compatibility of climate engineering with distributive and intergenerational justice. In the following chapter we will take up the final part of our research question that is the issue of procedural justice.

Chapter 6

Procedural Justice in Climate Engineering

6.1 Introduction

There is an inalienable bond between ends and means in ethics, which in itself is one of the hot topics of ethics.[1]The concerns with procedures are all the more overarching and self-imposing when it pertains to normative judgements over a pioneering and untested technology like climate engineering, the range of which is truly global. As a seminal technology still searching for its methods, standards, techniques and testing grounds and confronted with an array of uncertainties and side-effects, articulating the morally required procedures proper to it is extremely relevant and rewarding. Procedural justice stands tall among the contenders for the ethical analysis of climate engineering from the justice point of view. That explains the rationale for our focus on procedural justice in climate engineering in this chapter.

In the first part, glancing quickly over the present landscape of issues in procedural justice as exposed in the existing literature, we move on to developing a specific theoretical model of procedural justice drawing on John Rawls in the second part. The Rawlsian model of procedural justice is applied to the various procedural dynamics of the climate engineering debate in the third section that enables us to make some concrete recommendations in the final part. Accordingly our lead questions in this chapter will be: can the development of climate engineering be compatible with the Rawlsian view of procedural justice? What are the conditions under which a practice of climate engineering is procedurally fair and just from the Rawlsian point of view?

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[1] Means to an end is a popular coinage in philosophy referring to an action used for the purpose of achieving a goal. A major contention of the philosophy of ends and means is the justifiability of means by the ends. Some basic questions include, does the end justify the means? Can some means be used for achieving some ends? The issue has been debated almost from the beginnings of philosophy, particularly with the Aristotelian system. See, Aristotle, *Nicomachean Ethics: Books I to IV,* Translated by W. D. Ross (Kithchener: Batoche Books, 1999); Aquinas, *Summa Theologiae (A Treatise on Theology*), Parts I & II*; Catechism of the Catholic Church* (Massachusetts: The Crown Publishing Group, 2013)*;* A.I. Melden, Ed.,*Ethical Theories: A Book of Readings*, Translated by Lewis Beck White (Englewood Cliffs, NJ: Prentice-Hall, 1950).

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6.2 Review of Literature

6.2.1 Ethical Concerns

In the existing literature on procedural justice in climate engineering, Preston (2013 & 2014), Svoboda et al. (2011), Gardiner (2013) and Corner and Pidgeon (2013) deserve a special mention.Issues of participation and consent, questions about how to balance climate engineering efforts with mitigation efforts, how rapidly to ramp up the chosen technology, how to evaluate the impacts of the technology, what to set as targets, and which governance mechanism should take charge, and concerns about the security threats posed by the technology are the major issues of procedural justice voiced in the literature.

6.2.1.1 Consent and Participation

Preston (2013) and Svoboda et al. (2011) are the only papers that address the issue of procedural justice in climate engineering in a couple of paragraphs under the specific subtitle. Preston considers participation and consent to be formidable issues at the level of research and development as well as implementation. "If the problems of participation and consent first arise in the context of research, there is no doubt whatsoever that their reappearance in the context of implementation is one of the biggest ethical challenges climate engineering faces. As an engineering project promising global impacts, some form of consent—at least from the representatives of those affected—would appear to be a non-negotiable requirement of just procedure."[2]

Obtaining informed consent for climate engineering research is very problematic.[3] The principle of informed consent is traditionally focussed on participation in research and holds that a person who might participate in research should be adequately informed about the implications and risks of the research and his/her consent must be obtained for carrying out the research. In the case of climate engineering the conventional understanding of informed consent faces many limitations. It is difficult to clearly identify the parties who might be affected by climate engineering. There will be a huge number of people who will be affected by such a globally impactful technology. It is difficult to get a unanimous consent from a huge population. In that case, it may be argued that the representative consent of populations may be sufficient. However, the representative consent also involves several concerns. One might ask, for example, who is to represent whom, and what is the opinion to be represented? The desperate or self-defence scenarios as highlighted by Gardiner (2013)

[2] Preston 2013, p. 29.
[3] ETC 2009; Hale 2009; Hale2011; Morrow et al. 2009, p.4; Gardiner 2013b, pp. 28-29.

also invoke the issue of informed consent.[4] Assuming informed consent in a desperate scenario does not absorb the complexity of the problem.

Morrow et al. (2009) invoke the principle of respect as a motivation for obtaining consent for climate engineering. Their principle of respect, unlike the limited range of application of the same in the medical context, shows some adaptation to the global context of climate engineering in obtaining consent. They suggest "[…] the scientific community secure the global public's consent, voiced through their governmental representatives, before beginning any empirical research [on geoengineering]."[5]Svoboda et al. (2011) comment that the norm advocated by Morrow et al. (2009) will be helpful in satisfying the requirements of procedural justice as it precludes the public being affected by a policy to which they have not consented.[6]

6.2.1.2 Theoretical Models

Svoboda et al. (2011) look at the issue of procedural justice from the theoretical models of Rawls (1971), Norman Daniels and James Sabin (1998). Though limited to a small paragraph, Svoboda et al. (2011) think that unilateral deployment of SAG (Sulphate Aerosol Geoengineering) would violate the Rawlsian view of procedural justice, which requires that all parties who would be affected by a decision should be part of that decision. Unilateral SAG, cannot assume the consensus in the decision making process of all parties who would be affected by it. Svoboda et al.(2011) also list the four conditions of procedural justice laid down by Daniels and Sabin (1998): (1) that the rationales behind policy decisions be public, (2) that the rationales behind policy decisions be relevant to those decisions, (3) that policy decisions be subject to appeal, and (4) that there be mechanisms in place to enforce the other three conditions.[7] In their assessment of SAG from the perspective of Daniels and Sabin (1998), Svoboda et al. (2011)think that unilateral SAG would violate the last two conditions of procedural justice as there cannot be an appeal against the unilateral deployment as in climate engineering there is no governance mechanism in place to enforce such appeals. Preston (2013) also seems to presume the models of Rawls (1971) and Grasso[8] (2007) as he lists them under the references in his discussion on procedural justice.

[4] Gardiner 2013b.
[5] Morrow et al. 2009, p.1.
[6] Svoboda et al. 2011.
[7] Daniels and Sabin 1998, p. 57.
[8] M. Grasso, "A Normative Ethical Framework in Climate Change," *Climatic Change* 81 (2007): 223–246.

6.2.1.3 Public Engagement

Forming public opinion and ensuring public engagement from the beginning is a point forcefully stressed in the literature. There are at least 12 papers dealing with public engagement in climate engineering and that too on an optimistic note exploring various models of engaging the public.[9] Upstream public engagement,[10] supermajority rule,[11] and participatory democratic governance of bottom up model,[12] are some of the models proposed towards forming and appraising the public view on research into climate engineering.

6.2.1.4 Oxford Principles

Given the large scale and long-term impact of climate engineering some authors suggest treating climate engineering as a global public good.[13] The consideration of climate engineering as a public good was developed in the Oxford principles for climate engineering, which were developed and submitted to UK House of Commons in 2009.[14] The following are the five recommendations of the Oxford principles on climate engineering: 1.climate engineering should be treated and regulated as a public good. 2. There should be due participation of the public in the decision making on climate engineering. 3. The transparency of the research should be ensured with public disclosure of the research and its results should be published. 4. There should be independent assessment of the impacts of climate engineering. 5. Proper governance strategies should be developed before deployment.[15] Accordingly, the Oxford principles developed by Rayner et al.[16] (2009) are invoked by some authors in the debate over climate engineering.[17] Rayner et al. (2009) consider the climate engineering projects, including research and deployment, within the framework of the Oxford principles.[18] The Royal Society has also underscored the role of the public participation along

[9] Amelung 2012b, pp.41-48; Blackstock et al. 2009, p. 4; Corner and Pidgeon 2010; ETC 2009; Corner and Pidgeon 2010, p.32ff; Gramstad and Tjøtta 2010, p.13; Hulme 2009, pp.698-699; Parthasarathy et al. 2010; Prantl 2011, p.4; Preston 2013, p. 28; Macnaghten and Szerszynski 2013, p. 6ff; Poumaderel et al. 2011.
[10] Corner and Pidgeon 2010.
[11] Gramstad and Tjøtta 2010, p.13.
[12] Parthasarathy et al. 2010.
[13] Rayner 2011, p. 50; Preston 2013, p. 27.
[14] See also Chapter 3, 3.3.1.5.
[15] Rayner 2011. See also, Preston 2013, p. 27.
[16] Rayner et al. (2009a), "Memorandum on Draft Principles for the Conduct of Geoengineering Research," House of Commons Science and Technology Committee enquiry into the Regulation of Geoengineering, www.sbs.ox.ac.uk/research/sts/Documents/regulation-of-geoengineering.pdf. Accessed on February 19, 2016
[17] Feliciano 2013, p. 386; Kwa & van Hemert 2011, p. 6; Preston 2013, pp. 27-29.
[18] Rayner et al. 2009b.

similar lines calling for transparency of research. The Asilomar gathering[19] in March 2010 also endorsed the Oxford principles with some variation.

6.2.1.5 Unilateral Deployment

The fear of the unilateral deployment is a leading concern in the risk ethics with 13 references.[20]The leading position is that SAG should not be implemented unilaterally. The mere fact that unilateral SAG is procedurally unjust is not sufficient to establish that SAG as such is procedurally unjust. However, given that SAG is inexpensive and can be implemented without multilateral agreement, the prospect of unilateralism poses a challenge for SAG to meet the requirements of procedural justice. Advocates of a just form of SAG, assuming there is one, might urge the international community to develop safeguards against unilateralism. At any rate, it is the responsibility of proponents of SAG to recognize and address this potential problem.

6.2.1.6 Principles of Beneficence and Minimization

Many of the concerns with procedural justice in climate engineering are related to the issue of research and development. Morrow et al. (2009) have invoked the principles of beneficence and minimization to provide some tips towards doing research in climate engineering. They hold that the principle of beneficence, along with justice, requires that there should be a "favorable risk–benefit ratio and a fair distribution of risks and anticipated benefits […]." They also think that given the long time span of the deployment of technology and its effects, it will be difficult to achieve a favourable risk-benefit ratio for climate engineering experiments. According to the minimisation principle, the extent and intensity of the experiment should be kept to the minimum avoiding as much risks as possible due to unnecessary prolongation of the experiment. As of now, there is no adequate scientific knowledge about the possible risks and benefits. Therefore there is a real difficulty with the "risk-knowledge calculus."[21] Given this difficulty, Morrow et al. (2009) advocate a maximin approach towards the assessment of the risk-benefit ratio, whereby the population that is most risk-prone and least beneficiary will deserve the greatest ethical attention.[22]

[19] See Chapter 3, 3.2.2.1.
[20] Banerjee 2011, p.16; Virgoe 2009; Barrett 2008; Bodansky 1996; Goodell 2010, pp.195-197; Bracmort and Lattanzio 2013, p. i; Mooney et al. 2012, p.228; Resnik and Vallero 2011, p.8; Scholte et al. 2013, p.4.; Svoboda et al. 2011; Virgoe 2009, p. 115; Weitzman 2012; Parson 2013.
[21] Morrow et al. 2009, pp. 5-6.
[22] Morrow et al. 2009, p. 5.

6.2.1.7 Moratorium

The advocacy of a moratorium on research and development also obtains significance from the viewpoint of procedural justice. There are 8 papers dealing with a moratorium on climate engineering tests[23] though not directly in relation to procedural justice. Different variants of the precautionary principles are invoked by different authors. Some interpretations of the precautionary principle call for a ban or moratorium on climate engineering.[24] The weak version of the precautionary principle states that the precaution of avoiding harm should be given preference in case of a choice under uncertainty. There are several elements of uncertainty and potential risks in climate engineering. This is adequate reason for a ban on climate engineering as a precaution against the adverse impacts on the ecosystem. Besides, worries about moral hazard, and possible commercial misuse of technology are arguments listed for a ban or moratorium.

6.2.3 Comments on Procedural Justice in the Literature

Unlike the case of intergenerational justice, there is not a single paper exclusively dedicated to the issue of procedural justice or dealing with the topic in some detail. Procedural justice is very much an underdeveloped area in the debate, though it is very important at this phase of the debate. Though there were a few field tests already performed, which invited much public reaction, it does not seem to have caught the attention of the ethicists.

Although the issue of informed consent is emphasised, there is no clarity on the model of the consent to be followed in the case of climate engineering. The model assumed in most papers is the medical model of the informed consent. Given the international nature of the climate engineering technology, the feasibility of the public good model[25] needs to be explored. The public good model will need to use the representative model of decision making and the intricacies of the representative process of decision making in such a global project need to be analysed further. The suggestion of Morrow et al. (2009) recommending the application of the principle of respect, which holds that respect for the autonomy of participating subjects should be upheld in SAG, provides a useful model in this regard.

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[23] Cicerone 2006; ETC 2099; Leal-Arcas and Filis-Yelaghotis 2012, pp. 137-139.; Schneider 2008; Goodell 2010, p. 2000; Bracmort and Lattanzio 2013, p. 23; Mooney et al. 2012, p.224; Resnik and Vallero 2011, p.9.

[24] Bracmort and Lattanzio 2013, p.7; Mooney et al. 2012, p.224; Banerjee 2011, p. 27; Elliot 2010.

[25] See Chapter 3, 3.3.1.5.

Present engagements with procedural justice are confined to SRM methods and there is no single mention of the challenges of the CDR approaches to procedural justice. Svoboda et al. (2011) deserve special acknowledgement for recognizing that SAG need not be implemented unilaterally and the scope for unilateral SAG does not make climate engineering procedurally unjust.[26] It opens another direction to the debate to see if there is a procedurally just way of deploying climate engineering. The future course of the ethical debate in climate engineering should concentrate more on the possible ways and means of developing and deploying climate engineering in a procedurally just manner.

Though many of the issues relevant for procedural justice are dealt with in the literature, they are not systematically developed showing the particular implications of specific issues for procedural justice, for instance, the issue of moratorium or the principle of informed consent in research. These are some of the underdeveloped areas. There is no country specific assessment of the issues like moratorium, public engagement, etc., for climate engineering. Although there are clear historical instances of the weather modification being used for military intentions in the Vietnam War, it is not adequately addressed in the literature, with only one paper considering it as a major issue for procedural justice.[27] The emerging terrorist challenges deserve to be particularly appropriated. Summarising, the issue of procedural justice, except for its governance part, has significantly evaded the attention of the ethicists. It is this shortfall that we wish to partly address in the subsequent pages.

6.3 The Rawlsian View of Procedural Justice

As in the preceding chapters, we will use the theoretical frame of the Rawlsian view of procedural justice to see if the development of climate engineering can be compatible with procedural justice. Rawls has extensively dealt with procedural justice. Indeed, procedural justice intrinsically pertains to the Rawlsian scheme as his notion of original position is envisaged to offer the fair conditions for the contracting parties to reach at a just agreement. He develops his view of procedural justice mainly in his *Theory of Justice* (pp. 58, 73-77, 104, 118, 112, 173-174, 194, 267-291, 310-312, 318). His later works *Political Liberalism* (pp. 62, 72f., 225, 259, 282), and *Justice as Fairness* (pp. 50-57, 139-140, 156; 170-171) add extra elements to the perspectives advanced in *Theory of Justice*.

[26] Svoboda et al. 2011.
[27] Corner and Pidgeon 2010.

Rawls introduces the notion of procedural justice while illustrating the principle of fair equality of opportunity. For Rawls, the basic structure of the society is the primary subject matter of justice. The basic structure is a system of rules that assigns to each certain recognized claims to a share in the proceeds.[28] Accordingly, the question of distributive justice is a matter of ensuring the claims of each one to a share in the proceeds. Thus distributive justice is closely linked up with procedural justice. Procedural justice means that whatever the outcome may be, it will be just, provided the social system is designed so following the terms of the original agreement.[29]In *Theory of Justice*, Rawls introduces three concepts of procedural justice, namely,

- perfect procedural justice,
- imperfect procedural justice, and
- pure procedural justice.

Analysing the first two, Rawls moves on to his ideal view of procedural justice as pure procedural justice.

6.3.1 Perfect Procedural Justice

Rawls explains the characteristics of perfect procedural justice with the example of cutting a cake. Assuming that everyone getting an equal share is the fair division, the one who cuts the cake will claim his share after all others. The following definitive features could be identified here: "First, there is an independent criterion for what is a fair division, a criterion defined separately from and prior to the procedure which is to be followed. And second, it is possible to devise a procedure that is sure to give the desired outcome."[30] Rawls acknowledges that it is not applicable to employ perfect procedural justice in most practical cases.[31] In political processes there cannot be perfect procedural justice since voting will be needed in many cases.[32]

6.3.2 Imperfect Procedural Justice

Rawls uses the example of a criminal trial to illustrate the category of imperfect procedural justice. Ensuring justice in criminal trials means that the defendant is punished if

[28] See, Rawls, *Theory of Justice*, p. 74.
[29] See, Rawls, *Theory of Justice*, p. 74.
[30] Rawls, *Theory of Justice*, p. 74.
[31] Rawls, *Theory of Justice*, p. 74.
[32] Rawls, *Theory of Justice*, p. 311.

and only if he has committed the offence. The trial procedure is a search for truth in this regard. Despite strictly following the law and rightly following the procedure, it cannot assure just result always as it sometimes happens that an innocent person gets punished and the guilty goes free. Rawls calls the unjust result from imperfect procedural justice a "miscarriage of justice: the injustice springs from no human fault but from a fortuitous combination of circumstances which defeats the purpose of the legal rules."[33] "The characteristic mark of imperfect procedural justice is that while there is an independent criterion for the correct outcome, there is no feasible procedure which is sure to lead to it."[34]

Rawls considers a just constitution to be an instance of imperfect procedural justice. "The constitution is regarded as a just but imperfect procedure framed as far as the circumstances permit to insure a just outcome. It is imperfect because there is no feasible political process which guarantees that the laws enacted in accordance with it will be just."[35]

6.3.3 Pure procedural Justice

The limitations of perfect procedural justice – not applicable in most practical cases for want of a perfect criterion – and of imperfect procedural justice – there is no feasible procedure which is sure to lead to right outcome – are overcome in the category of pure procedural justice. Pure procedural justice is invoked in the absence of an independent criterion for the right result. It is pure because "... the outcome is ... correct or fair, whatever it is, provided that the procedure has been properly followed."[36] Rawls uses the example of gambling to illustrate pure procedural justice. In a fair gambling by a number of persons, the final distribution of cash is fair whatever the distribution is, provided the bet is voluntary and there is no cheating. In the bet, although the final distribution may not be equal among parties, as far as the procedure is concerned, all betting parties have the equal opportunity to gain the highest from the bet. Here there is no standard criterion to determine the outcome. However, the fair procedure being carried out alone ensures that the result is fair. "A fair procedure translates its fairness to the outcome only when it is actually carried out."[37] This is the point about pure procedural justice. Accordingly, Rawls calls for impartial social systems that would facilitate a just social structure. "In order, therefore, to apply the notion of pure procedural justice to distributive shares it is necessary to set up and to administer impartially

[33] Rawls, *Theory of Justice*, p. 75.
[34] Rawls, *Theory of Justice*, p. 75.
[35] Rawls, *Theory of Justice*, p. 311.
[36] Rawls, *Theory of Justice*, p. 75.
[37] Rawls, *Theory of Justice*, p. 75.

a just system of institutions. Only against the background of a just basic structure, including a just political constitution and a just arrangement of economic and social institutions, can one say that the requisite just procedure exists."[38]

Rawls thinks that pure procedural justice has the practical advantage of standing up to any unforeseen circumstances without engaging the details of such circumstances. "Now the practical advantage of pure procedural justice is that it is no longer necessary to keep track of the endless variety of circumstances and the changing relative positions of particular persons. One avoids the problem of defining principles to cope with the enormous complexities which would arise if such details were relevant."[39]

Pure procedural justice has to be seen from the viewpoint of the original position. As we have seen in chapters 4 and 5, the entire Rawlsian scheme is built up on the hypothetical notion of the original position. If the agreement between parties is drawn by fulfilling the conditions of the original position, that in itself assures procedural justice. "The idea of the original position is to set up a fair procedure so that any principles agreed to will be just. The aim is to use the notion of pure procedural justice as a basis of theory."[40] The state of affairs in the original position is such that any agreement reached at will be procedurally fair, because in the original position all parties are equally represented and there are no arbitrary contingencies or a relative balancing of social forces.[41] Therefore, in the Rawlsian view of *Justice as Fairness*, pure procedural justice will be present from the beginning.

Rawls also sees that there are occasions when it is possible only to have a quasi-pure procedural justice. Quasi-pure procedural justice occurs when "... laws and policies are just provided that they lie within the allowed range, and the legislature, in ways authorized by a just constitution, has in fact enacted them."[42] An instance of the quasi-pure procedural justice is the choice of the just constitution and the enactment of the just laws and policies at the legislative stage.[43] There is an element of indeterminacy in the adoption of the constitution, or

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[38] Rawls, *Theory of Justice*, p. 76.
[39] Rawls, *Theory of Justice*, p. 76.
[40] Rawls, *Theory of Justice*, p. 118.
[41] Rawls, *Theory of Justice*, p. 104.
[42] Rawls, *Theory of Justice*, p. 176.
[43] Rawls envisages a four-stage sequence for the formation of the contract, namely, the original position, the constitutional stage, the legislative stage and the stage of governance and administration. "[T]he four-stage sequence is a device for applying the principles of justice. This scheme is part of the theory of justice as fairness and not an account of how constitutional conventions and legislatures actually proceed. It sets out a series of points of view from which the different problems of justice are to be settled, each point of view inheriting the constraints adopted at the preceding stages" (Rawls, *Theory of Justice*, p. 318).

the economic and social policy, as to which will be chosen from among the several ones. Conversely, justice also becomes indeterminate. “Thus” Rawls feels that “on many questions of social and economic policy we must fall back upon a notion of quasi-pure procedural justice.”[44] It occurs also in cases of political settlement by majority rule. Under the principle of political settlement, “... if the law actually voted is, so far as one can ascertain, within the range of those that could reasonably be favored by rational legislators conscientiously trying to follow the principles of justice, then the decision of the majority is practically authoritative, though not definitive. The situation is one of quasi-pure procedural justice.”[45] Pure procedural justice cannot be achieved in instances of political settlement because the right result is not assured therein, for there are people who disagree with the majority whose interests are not recognized in the final result.[46]

Rawls has also found that pure procedural justice is operative in deciding the fair wages under the veil of ignorance. The choice of the just institution of fair wages can be ideally decided under the veil of ignorance.[47] Therefore, the parties will avoid wage inequalities in deciding on the minimum wages. “Variations in wages and income and the perquisites of position are simply to influence these choices so that the end result accords with efficiency and justice.”[48] It will also be found that wage inequalities will be necessary to facilitate the overall performance of the economy. Inasmuch as minimum wages and the income are decided following the fair and just deliberations under the veil, they will be instances of pure procedural justice.

6.3.4 Procedural Justice in *Political Liberalism*

In *Political Liberalism*, Rawls reinstates the same view of procedural justice developed in *Theory of Justice* but expands it with certain additional elements. Rawls holds that the original position is a case of pure procedural justice and rational autonomy is modelled in the original position.[49] As in *Theory*, he contrasts it with perfect procedural

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[44] Rawls, *Theory of Justice*, p. 176.
[45] Rawls, *Theory of Justice*, p. 318.
[46] Rawls, *Theory or Justice*, p. 318.
[47] Roemer comments on Rawls in this regard that deliberations under the veil will lead to a maximin formulation, for it is assumed that decision makers are very much aversive to risk (Roemer 1996). See also, David A. Green, What is a minimum wage for? Empirical Results and Theories of Justice, IFS Working Paper W14/24. Available at https://www.ifs.org.uk/uploads/publications/wps/WP201424.pdf. Accessed March 13, 2015.
[48] Rawls, *Theory of Justice*, p. 277.
[49] See, *Political Liberalism*, pp. 72, 225. By rational autonomy Rawls means, “... persons’ intellectual and moral powers. It is shown in their exercising their capacity to form, to revise, and to pursue a conception of the good,

justice: "This contrasts with perfect procedural justice, where there is an independent and already given criterion of what is just (or fair), and the procedure can be designed to insure an outcome satisfying that criterion.... The essential feature of pure procedural justice, as opposed to perfect procedural justice, is that what is just is specified by the outcome of the procedure, whatever it may be. There is no prior and already given criterion against which the outcome is to be checked."[50]

In *Political Liberalism*, "Pure procedural justice means that in their rational deliberations the parties do not view themselves as required to apply, or as bound by, any antecedently given principles of right and justice. Put another way, they recognize no standpoint external to their own point of view as rational representatives from which they are constrained by prior and independent principles of justice."[51] Here there is no role for any outside authority like God's law.

He defines pure procedural justice in relation to the two principles of justice (equal liberty and fair equality of opportunity). These principles incorporate pure procedural justice and they apply to the basic structure. Further, fair procedures should be actually carried out. "A fair distribution can be arrived at only by the actual working of a fair social process over time in the course of which, in accordance with publicly announced rules, entitlements are earned and honored. These features define pure procedural justice."[52] In *Political Liberalism,* Rawls argues that pure procedural justice is invoked at the highest level. In justice as fairness the parties are thought of as free and equal moral persons, and the content of the agreement is the first principles that regulate the basic structure. Accordingly, "...the content of justice for the basic structure can be ascertained, or at least approximated, by the principles that would be adopted. ... Thus pure procedural justice is invoked at the highest level: the fairness of the circumstances transfers to fairness of the principles acknowledged."[53]

In *Political Liberalism,* Rawls underscores the connection between substantive justice and procedural justice.[54] For Rawls, the distinction between procedural justice and substantive justice is only a distinction between the justice of a process and the justice of its

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and to deliberate in accordance with it. It is shown also in their capacity to enter into an agreement with others (when subject to reasonable constraints)." *Political Liberalism*, p. 72.

[50] Rawls, *Political Liberalism,* p. 73.

[51] Rawls, *Political Liberalism*, p. 73.

[52] Rawls, *Political Liberalism,* p. 282.

[53]Rawls, *Political Liberalism*, p. 259.

[54] This is affirmed in response to the criticism of Habermas (1987) against Rawls. See, *Political Liberalism,* p. 421. Habermas, *The Theory of Communicative Action*, Vol. 2, *System and Lifeworld,* Translated by McCarthy (Boston: Beacon, 1987).

outcome.[55] Both exemplify values of procedure and outcome and they go hand in hand as the justice of a procedure depends on the value of the outcome. Thus, "... fair procedures have values intrinsic to them..."[56] Revisiting his examples of perfect and imperfect procedural justice – cutting a cake and criminal trial respectively - Rawls shows how there can be no just outcome without a just procedure and no just procedure without a just outcome. Similarly, he proves the same point by analysing majority-rule in democracy, that constitutionalists and majoritarians may agree that justice in majority democracy is founded on whether its outcomes are substantively just.[57]

6.3.5 Procedural Justice in *Justice as Fairness*

Rawls had emphasised the importance of background conditions for pure procedural justice. That is what he technically confirms by introducing the term background to procedural justice in *Justice as Fairness*. Rawls sees that allocative justice is incompatible with justice as fairness. The distribution of wealth in a well-ordered society does not warrant allocative justice, and takes care of the background procedural justice by itself. "In a well-ordered society, in which both the equal basic liberties (with their fair value) and fair equality of opportunity are secured, the distribution of income and wealth illustrates what we may call pure background procedural justice."[58] With the term "background," Rawls means that "certain rules must be included in the basic structure as a system of social cooperation so that this system remains fair over time, from one generation to the next."[59] These rules are necessary to maintain background justice like the fair value of the political liberties, fair equality of opportunity, and difference principle. The demands of the difference principle are part of fair social cooperation in justice as fairness.

Rawls holds that distributive justice could be understood as a case of pure procedural justice even with these rules of background justice. "Taking the basic structure as the primary subject enables us to regard distributive justice as a case of pure background procedural justice: when everyone follows the publicly recognized rules of cooperation, the particular distribution that results is acceptable as just whatever that distribution turns out to be.... This allows us to abstract from the enormous complexities of the innumerable transactions of daily

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[55] Rawls, *Political Liberalism*, p. 421.
[56] Rawls, *Political Liberalism*, pp. 421-422.
[57] Rawls, *Political Liberalism*, p. 423f.
[58] Rawls, *Justice as Fairness*, p. 50.
[59] Rawls, *Justice as Fairness*, p. 51.

life and frees us from having to keep track of the changing relative positions of particular individuals."[60]

The primacy of the basic structure and the added emphasis on it is the novelty of the procedural justice in *Justice as Fairness*. Rawls articulates, "...we take the basic structure as the primary subject. This structure comprises social institutions within which human beings may develop their moral powers and become fully cooperating members of a society of free and equal citizens. And as a framework that preserves background justice over time from one generation to the next it realizes the idea (central to justice as fairness) of pure background procedural justice as an ideal social process (as explained under the first kind of reason)."[61]

Rawls also emphasises some concrete strategies to ensure pure background procedural justice from generation to generation. Entrusting sufficient productive means to general population and not to a few is important. Such means include "... human as well as real capital, that is, knowledge and an understanding of institutions, educated abilities, and trained skills."[62]

But there are differences in the basic capabilities of individuals. Further, a scientific measure of these capabilities is impossible as well. However, Rawls holds that adjustments to these differing capabilities will naturally proceed "... by way of an ongoing social process of pure background procedural justice in which qualifications suitable for particular offices and positions play a distributive role."[63] Thus no political injustice will be caused by the differences in basic capabilities.

6.4Climate Engineering in the Rawlsian View of Procedural Justice

In this section we will take up our lead question, can climate engineering be developed in a manner compatible with the Rawlsian concept of procedural justice and what are the conditions for climate engineering to meet the Rawlsian view of procedural justice.

6.4.1Which Category of Procedural Justice?

It is necessary to identify the category of procedural justice that is most suited for application to climate engineering, from among the three categories, namely, pure, perfect and imperfect justice. Is climate engineering compatible with all three categories? Thanks to

[60] Rawls, *Justice as Fairness*, p. 54.
[61] Rawls, *Justice as Fairness*, p. 57.
[62] Rawls, *Justice as Fairness*, p. 140.
[63] Rawls, *Justice as Fairness*, p. 171.

the enormous complexities in climate engineering, such a claim is frivolous. For perfect procedural justice to be suitable there should be an independent criterion; that criterion should be defined prior to the procedure; and there should be a procedure that can achieve the desired result according to the criterion.[64]The issue of fairness in climate engineering is not anything as simple as cutting a cake. Climate engineering technology is still at the conceptual level without any major field test having been performed. It is loaded with a huge amount of uncertainties in regard to its outreach, impacts, and side-effects. Therefore it is impossible to define an independent criterion, let alone prior to the procedure, and conversely the issue of devising a procedure to that effect does not occur. Thus perfect procedural justice is inapplicable in climate engineering. Rawls himself has acknowledged that perfect procedural justice does not hold up in most practical cases.[65]

On the same ground it can be seen that imperfect procedural justice too does not hold up in the context of climate engineering. Imperfect procedural justice requires an independent criterion, and despite the right recourse to the procedures, the procedure is vulnerable to unjust results. It is clear that without an independent criterion and being unable to devise the proper procedures, it is sure to result in what Rawls describes as a miscarriage of justice.

Pure procedural justice holds that the outcome will be just provided the procedure is fair. Inasmuch as the result is just based on a fair procedure, there cannot be an ethical objection to climate engineering. If for research and application of climate engineering a procedure can be devised that is fair in every respect and can lead to just results in every aspect, pure procedural justice does hold for climate engineering. Pure procedural justice in its ideal vision offers a solution to the problems of uncertainties and known and unknown side-effects that is crucial in climate engineering. From the Rawlsian perspective, whatever the uncertainties or side-effects maybe, pure procedural justice should have a fair system to tackle them in order to ensure that the result is just. According to Rawls, in pure procedural justice one can avoid the trouble of keeping track of the endless variety of circumstances and of defining principles to cope with the enormous complexities that may arise.[66]Although realizing such a project is more ambitious than practical given the looming uncertainties in climate engineering, if it indeed can be translated into reality eventually, that will be a sufficient reason for climate engineeringbeing procedurallyjust. Therefore, our intersection

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[64] Rawls, *Theory of Justice*, p. 74.
[65] Rawls, *Theory of Justice*, p. 74.
[66] Rawls, *Theory of Justice*, p. 76.

between Rawls and climate engineering will be from the point of view of pure procedural justice.

6.4.2Pure Procedural Justice and the Basic Structure

For Rawls ,"[T]he basic structure is the primary subject of justice."[67]"[P]rocedural justice presupposes that the basic structure satisfies the two principles (of equal liberty and fair equality of opportunity."[68]Therefore, it needs to be examined whether climate engineering ensures a basic structure that meets the condition of satisfying these two principles. Let us see the meaning of basic structure in Rawls."The basic structure is a public system of rules defining a scheme of activities that leads men to act together so as to produce a greater sum of benefits and assign to each certain recognized claims to a share in the proceeds."[69] If climate engineering produces greater benefits and assigns each one certain claims, it could be said to be meeting the condition of satisfying the two principles of justice and as such one could move on to formulating the principles of procedural justice.

But, can climate engineering meet the conditions of the basic structure of the society? Is climate engineering capable of producing a greater sum of benefits? Does it assign to each certain recognized claims to a share in the proceeds? As the present implications of climate engineering go, all these questions are to be answered in the negative. As we have seen, as a last resort option or a lesser evil choice, climate engineering is not considered to be a technique that can fundamentally enhance the benefits of the society. It is true that some of the hardcore proponents think that it has incredible economics[70] that can outsmart the economic challenges of mitigation. Even in that regard, however, the benefits accrued are estimated only relative to mitigation. Yet, critical scrutiny of such claims has shown that the rhetoric of incredible economics are quite artificial as they completely ignore the indirect expenses as well as the issues of compensation or the expenses pertaining to unforeseen side-effects. Thus, neither the lesser evil argument nor the economic feasibility argument can assure that climate engineering will produce a greater sum of benefits. On the contrary, climate engineering has the potential to compound the dangers to climate change due to accumulated CO_2leading to a potential catastrophe. Secondly, as regards ensuring the claims to each one, we have seen in the fourth chapter that climate engineering will certainly

[67] Rawls, *Theory of Justice*, p.73.
[68] Rawls, *Theory of Justice*, p. 168. See Chapter 4, 4.3.3.
[69] Rawls, *Theory of Justice*, p. 74.
[70] See, Barret 2014.

produce winners and losers.[71] Therefore, even if it brings certain claims to a share in the proceeds, that share will not be equal and fair to all, but rather at the cost of the losers. Pure procedural justice should meet the condition of the fair equality of opportunity. Now we see that climate engineering cannot meet this condition.

The proponents might argue that enabling each nation to unilateral deployment ensures certain equality of claim. But we will see below that as regards procedural justice, unilateral deployment is an intrinsic contradiction as the impact of regional deployment can be global and there is no way of balancing the interests of all parties if one party unilaterally decides to deploy climate engineering. Further, given the technological upper hand or monopoly of the rich countries today, it will be mythical to assume that all parties will be equally equipped to deploy climate engineering. Therefore, climate engineering from the Rawlsian point of view cannot meet the conditions of the basic structure for applying pure procedural justice that the two basic principles of justice like equal liberty and fair equality of opportunity are to be satisfied.

6.4.3Background Pure Procedural Justice and Restoration of Climatic Justice

Continuing along the line of our arguments in the preceding section, in this section, drawing clues from the Rawlsian emphasis on setting the background conditions right for justice, we will argue that in order to meet the demands of the Rawlsian pure procedural justice in climate engineering, first ethicists will have to fix the "climatic injustice"[72] that is prevalent in the world today. Even if a perfect governance system and all other mechanisms are in place including agreements on compensation for ensuring just results, it remains that from the Rawlsian point of view, pure procedural justice will be far from complete unless basic institutions are established in order to ensure equal liberty to all and fair equality of opportunity, for justice pertains to the basic structure and the basic structure of the climate change context today is disturbingly unjust. As Rawls holds: "In order ... to apply the notion of pure procedural justice to distributive shares it is necessary to set up and to administer impartially a just system of institutions. Only against the background of a just basic structure, including a just political constitution and a just arrangement of economic and social institutions, can one say that the requisite just procedure exists."[73] Without restoring climatic

[71] See, Chapter 4, 4.4.1.
[72] The term was coined by Preston 2014.
[73] Rawls, *Theory of Justice*, p. 76.

justice, in the case of climate engineering, "...the basic structure is a case of imperfect procedural justice."[74]

In the Rawlsian scheme, parties in the original position are entering into a contract as contemporaries. The nature of the original position is such that it should be possible to consider any point of time as the entry-time. Let us assume that the nations of the world are the parties today that sit together to form the fair procedures to facilitate the deployment of climate engineering as a tool to combat dangerous climate change. The Rawlsian veil of ignorance is partly lifted so as to permit the parties to know the essential setting of the challenges of climate change, the potentials of climate engineering to combat it, the far-reaching consequences of climate engineering, and more importantly, the present environmental and economic state of affairs with individual nations. However, the veil of ignorance holds up in regard to which nation each contracting party represents.

Understandably, the parties find the basic structure of the society to be highly uneven in several respects including the geographical and economic vulnerability to climate change.[75] They also find that countries are differentiated in terms of their responsibility to climate change with the paradoxical observation that some of the least responsible countries are the most vulnerable to the climate change. Within the pristine environment of a veil of ignorance as to their national affiliation, in analysing the dangerous climate change, they will be shocked to see several nations of the world overshooting by several fold their bio-capacity and eco-footprint, and several other nations being deprived of their otherwise deserving portion of productive land and fresh waters to alarming proportions. For instance, partly on account of "geographical bad luck"[76]Sub-Saharan countries are largely undeveloped and conversely least responsible for climate change, but most vulnerable to the dangers of climate change. Canada has overshot its eco-footprint four times above the global average, whereas the eco-footprint of Bangladesh is half the global average.[77] In the meantime the parties in the original position find in their deliberations based on the available scientific predictions[78]that Canadians will further benefit from climate engineering and conversely Bangladesh will lose

[74] Rawls, *Theory of Justice*, p. 77. A nominal gesture of acknowledging this fact is the recognition of the differentiated responsibility for climate change in the Paris summit.
[75] See, Preston 2014, p. 83.
[76] The phrase is of Preston 2014, p.74.
[77] See, Mathis Wackernagel et al., "National Natural Capital Accounting with the Ecological Footprint Concept," in *Ecological Economics* 29 (1999): 375–390. We are aware that there are no 'Canadians' or 'Bangladeshis' in the original position. These references are used only to clarify the argument.
[78] See, Bunzl 2011.

further as one of the nations to be hit worst by the potential side-effects of climate engineering. In the first place, the parties identify the irony that climate engineering will reinforce and compound the injustice already perpetuated in the present scenario.

The basic structure of the climate engineering society can be structurally just subject to the just nature of the procedures in defining the basic structure of the pre-climate engineering society. Ensuring procedural justice in a future climate engineering society has to begin with rectifying the disequilibrium of justice in regard to climate change in the present world. The Rawlsian view of procedural justice cautions the climate engineering theorists about the gravity, complexity and radicality of the homework that needs to be done to prepare ethically for climate engineering.

The concept of the desert advocated by Sher (1987)[79]comes into force here. Desert means that one does deserve something even though one does not have the right to obtain it. To understand it with a simple example, say, two persons walking on the road, one stomach-full and the other hungry for several days. On the way they find a food stall offering a single free burger. Common sense tells us that the hungry man does deserve it more than the other. It is this pre-reflective level of right - that something in us that entitles the hungry among the two to the burger- that is to be termed as desert. Our present ethical deliberations are revolving mostly around the concept of rights and obligations. In fact, our concepts of rights act as a vindication against our 'desert-like obligations' to others. For instance, I have plenty of money earned through fair means. My country's constitution permits private property. And hence I have no legal obligation[80] to share my money with the poor. Nobody has a right over my money and I do not need feel morally obliged to anybody. My awareness of my right to my private wealth relieves me of my subjectively-driven moral compulsion to help the needy. In other words, desert lacks necessary normative force to lead someone to action. And if people can voluntarily strip themselves of their legitimate rights, there would not be so much divide between the haves and the have-nots in the world. But desert has no such binding force in the array of ethical disputes dominated by rights and obligations. That so much of desert-like moral impulses remain unfulfilled in the world at large is the reason for so much "climatic injustice" – environmental and economic vulnerabilities suffered by many regions merely due to their geographical bad luck – prevailing today.

[79] See, Sher 1987.

[80]It can be seen that desert becomes non-obligatory only in the legal sense as the party may still be under moral obligation to share wealth depending on the norm or the theory employed.

Understanding desert under the Rawlsian scheme, we find that, perhaps, desert is at its best in Rawls. The moral force therein, however self-interested the parties may be, is the force of the desert. More precisely, in the original position, desert becomes the normative force of their self-interest. That is to say, since the parties in the original position being ignorant of their background and have nothing subjective to safeguard, the desert-like moral impulses will have a decisive role to play in their deliberations. At that pre-emptive level of rights and obligations, driven by desert-like moral impulses, the parties are very likely to rectify any disequilibrium in the existing scenario and try to perpetuate that equilibrium for future, progressively of course, due to their self-interest. Thus the primary structure is likely to have embodied fully the desert-like motivations which otherwise would have been conditioned by several extraneous factors. Strategically, this is very helpful for climatic justice and climate engineering justice. It is against this background that parties in the original position have to develop fair and just rules of procedure that ensure just results for climate engineering. Now, even as they begin to formulate principles, the proverbial saying that prevention is better than cure, as an intuitive normative credential of the human thinking, begins to be operative in this setting, and they take guard against any potential challenges to justice.

Given this strategy, the root of the justice concerns in climate engineering is addressed. It brings us back to the mainstream allegation against climate engineering that it does not address the root of the problem. Rawls underscores that only by fixing the issues at the root of the problem can the concerns of justice in climate engineering be discussed. If we can develop the proper procedural rules applying which just results can be ensured under any circumstance against all uncertainty and known and unknown side-effects, then climate engineering is procedurally just from the Rawlsian point of view. More than that, climate engineering would then be a great opportunity to redress many prevailing instances of injustice in the environmental setting. However, such a rosy scenario, though ideally desirable is hard to achieve against the real challenges, a point we discuss right below.

6.4.4Intersecting Procedural Justice and Distributive Justice

The Rawlsian veil of ignorance can remove the subjective circumstantial conditioning of the contracting parties. Under the veil of ignorance, the self-interest of the parties can positively act as a normative catalyst to rectify the degree of climatic injustice or imbalance currently existing in the system, for in a system freed from self-interests it is normative to give privileged attention to imbalances, especially when each contracting party considers the possibility of ending up on the otherwise vulnerable end of the system, when the veil of ignorance is lifted. Therefore, in the Rawlsian understanding of procedural justice it is not only mandatory to listen to the voice of the vulnerable, but they also get privileged attention in the processes of formulating the just rules of procedures. Here we identify a kind of the Rawlsian difference principle naturally establishing itself in the contracting deliberations.

It is a major contention in Rawls that distributive justice is ensured by pure procedural justice. "A distribution cannot be judged in isolation from the system of which it is the outcome or from what individuals have done in good faith in the light of established expectations."[81] "A fair distribution can be arrived at only by the actual working of a fair social process over time...."[82]In chapter 4 while analysing climate engineering from the Rawlsian viewpoint of distributive justice, we have seen that climate engineering and distributive justice will not go hand in hand as climate engineering would create winners and losers. Whereas here we find that fair distribution resulting from fair procedures leaves no room open for "an underclass."[83] In the Rawlsian scheme of pure procedural justice, in regard to climate engineering, leaving aside the practical concerns, at least theoretically we can "... hope that an underclass will not exist; or, if there is a small such class, that it is the result of social conditions we do not know how to change, or perhaps cannot even identify or understand."[84]

Herein lays the relevance of the new notion of background pure procedural justice that Rawls coined in *Justice as Fairness*. In *Justice as Fairness*, distributive justice is a case of pure background procedural justice. "Taking the basic structure as the primary subject enables us to regard distributive justice as a case of pure background procedural justice: when everyone follows the publicly recognized rules of cooperation, the particular distribution that results is acceptable as just whatever that distribution turns out to be..."[85] In such an ideal state of affairs where all just institutions are already in place for ensuring just results irrespective of any side-effects or unforeseen consequences for every citizen in the post-geoengineered world, it is procedurally just to develop climate engineering, or the desirability of climate engineering is justified only under such ideal conditions. That is to say, if a

[81] Rawls, *Theory of Justice*, p. 76.
[82] Rawls, *Political Liberalism*, p. 282.
[83] Rawls, *Justice as Fairness*, p. 140.
[84] Rawls, *Justice as Fairness*, p. 140.
[85] Rawls, *Justice as Fairness*, p. 54.

currently rich Canadian who enters as a party to the contract under the Rawlsian veil of ignorance (assuming permitting knowledge of nationality) finds that his self-interest is well protected though he would find himself as an Ugandan in the geoengineered world, then we could be confident that the Rawlsian conditions for pure procedural justice are somewhat met.

However, it is plain that such a rosy scenario is counterfactual and far from being visualised, let alone materialised. In the Rawlsian terms, fair procedure will have to consider special circumstances. Considering the manifold scientific, ecological, social, economic political consequences of such a pioneering technology, of which humanity has no foreknowledge, seems rationally impossible. Since fair procedure requires consideration of all circumstances and very little special circumstances are known or anticipated in climate engineering today, it is difficult to endorse climate engineering. Anticipating all results to ensure justice in the absence of an independent criterion and following a fair procedure to ensure justice even if all results are not anticipated are counterintuitive. Climate engineering technology is such that the outcome or results could be beyond the range of all anticipated contexts, invalidating all provisions already agreed upon, or allowing little time for deploying the compensatory mechanisms to share the loss. For example, the case of a double catastrophe[86] can be beyond the reach of the imagination of climate engineering, where there is little time for repairing the damage and human species on earth may be irrevocably lost not to be possible to restore a just result. It is our practical experience that despite all the predictions and security measures being deployed against a hurricane, there are irrevocable casualties. Determining the causal connection between climate engineering and the consequences like the reduced fish yield due to a CDR technique, or reduction in precipitation due to SRM, is still a contentious concern too hard to domesticate for fair procedure and just results. Ensuring procedural justice from the Rawlsian point of view of pure procedural justice will be a real test of human imagination, farsightedness and human preparedness for the unexpected.

It is doubtful whether there could be a fair procedure for deploying a technology that can no longer be revoked. Given the present rudimentary level of the climate engineering technology, the complementarity between fair procedure and just result seems to be an intrinsic impossibility standing against each other in climate engineering. For instance, it is

[86] See, Baum et al. 2013.

difficult to devise fair procedures to ensure just results without field test. But the issue of research and development is already contentious in climate engineering. Research and development itself warrant fair procedure and just results from the Rawlsian point of view. Conversely, the question now is: can there be a just procedure for research and development from the Rawlsian point of view? In climate engineering, field tests are necessary to know the outcome, for without tests, given the amount of uncertainty in climate engineering, there is no way to determine the outcome. In the Rawlsian terms, without anticipating the outcome of the field test, as of now, there cannot be a "purely" fair procedure for the field test. Thus, from the Rawlsian point of view, research and development cannot take place by meeting all the components of pure procedural justice that ensures just result. Simply put, developing a full-proof just procedure that can ensure just outcome for climate engineering is intrinsically impossible with the available scientific and technological knowledge about climate engineering today.

It might be objected that the Rawlsian pure procedural justice does not go into all the details as for him justice pertains to the basic structure of the society. After all in Rawls, the advantage of pure procedural justice is that one can avoid the trouble of keeping track of the endless variety of circumstances and of defining principles to cope with the enormous complexities that may arise.[87]In reply, however, it could be argued that the complexity of climate engineering is so foundational that it can destroy the very fundamental structure of the society, or worse, society itself, to which justice pertains in Rawls. Therefore, a fairness of procedure at the theoretical level cannot be expected to be carried out on the practical ground. It reminds us of another important strand in the Rawlsian view of procedural justice. Rawls says, "A fair procedure translates its fairness to the outcome only when it is actually carried out."[88]In *Political Liberalism,* Rawls argued that pure procedural justice is invoked at the highest level and pure procedural justice at the highest level implied that "A fair distribution can be arrived at only by the actual working of a fair social process over time..."[89]Even if there is a potentially pure procedure that can be devised unless it is actually carried out, it does not ensure just outcome. It is at this level of *carrying out* the fair procedure that we encounter real difficulties.

[87] Rawls, *Theory of Justice*, p. 76.
[88] Rawls, *Theory of Justice*, p. 75.
[89] Rawls, *Political Liberalism*, p. 282.

While the Rawlsian theory of procedural justice deals with the distribution of resources in an ideal society based on co-operation for “mutual advantage,”[90] in the climate engineeringsetting it is also a matter of ensuring the availability of resources for distribution, for, if climate engineering techniques are deployed, the consequences can be such that the very availability of essential commodity for sustenance can be at stake, as shown by the scientific estimations of the side-effects of climate engineering.

Therefore, although it may appear that climate engineering may be procedurally just in the eyes of the of the Rawlsian pure procedural justice, engaging the intricacies of the said suggestion we find that such a suggestion is only apparent and the justification of climate engineering from the Rawlsian viewpoint of pure procedural justice is highly dubious.

6.4.5 Consent – A Moral Quandary for Pure Procedural Justice

In effecting just results from fair procedure under the Rawlsian scheme, the climate engineering debate is confronted with a number of other practical issues in regard to procedural justice. For Rawls, just outcome is guaranteed by previously agreed rules. It takes us to the issue of consent in climate engineering. It is to be noted that here we are using consent in the Rawlsian sense as full mutual agreement on a social contract and not as acceptance of specific treatment as in the medical setting.The issue of consent has the potential to create a real moral dilemma in the climate engineering context. Rawls places the issue of consent at the foundational level as his whole system is built up on the mutual “consent” among the contracting parties in the original position. Treating the issue of consent in its conventional sense in the medical setting, lacks any merit in the climate engineering context for unlike the limited number of subjects who need to give consent in the medical setting, the participating subjects in climate engineering are all citizens on the globe, for climate engineering has such a global impact.

In the climate engineering context, who are the contracting parties: each human of this world or each individual nation? Considering the former, it is against all odds that all citizens of all nations are reached at and consent is obtained. Even if all individuals were reached at and if there were no unanimous endorsement, it would still be unclear what is the benchmark for deciding upon the consent, majority or a supermajority, as proposed by some authors? An

[90] Rawls, *Political Liberalism*, p. 84.

agreement by majority or supermajority is fairly democratic, but not Rawlsian. In majority rule, the interests of the losing position are not recognized and hence a case of imperfect procedural justice.[91]According to "…a social contract is a hypothetical agreement ... between *all rather than some members of society..."*[92] Obtaining consent for climate engineering seems to be a real procedural impossibility from the Rawlsian point of view. Without consent there cannot be a just procedure in place to ensure a just result as warranted by pure procedural justice.

If individual nations are considered as the contracting parties, the dilemma is only aggravated. Even within democratic nations today, the institutions of the society or the practice of distribution within nations are not established on just principles, as the disparity between the poor and the rich is a startling reality in the supposedly social and liberal economies. Particularly in climatic context, the ability to adaptation and vulnerability to climate changes vary in different regions or depending on the economic status of the population, often exposing the poor regions or poor citizens to greater risk. If the media reports can be believed, this was proven in the case of the preparations for and response to the hurricane Katrina that hit the United States in 2005. It also remains so that the voice of the poor sections of the society is often not given its due merit in the present practice of the policy making in almost all nations, as the policy makers and decision making process are very much marred by several extraneous factors like corporate influences. Therefore, even if there is consent among all nations, it is not likely to be a fair representation of the voices of all peoples of the nations. Absence of fair representation of the voices of all peoples is thus deemed to be an instance of imperfect procedural justice. Universal consent among all nations seems to be mythical given that climate engineering will certainly create losers and winners, and the potentially losing nations will not give consent to a technology that can be existentially catastrophic to them. Thus the issue of consent poses added challenges to procedural justice in climate engineering from the Rawlsian viewpoint of pure procedural justice.

6.4.6 Public Good and Public Engagement in the Rawlsian Perspective

According to Rawls, fairness requires that, in "... public political life, nothing need be hidden... there is no need for the illusions and delusions of ideology for society to work

[91] Rawls, *Theory of Justice*, p. 311.
[92] Rawls, *Political Liberalism*, p. 258.

properly and for citizens to accept it willingly."[93] This offers a key to addressing another element of the climate engineering debate from the point of view of procedural justice: treating climate engineering as a public good. As we have seen in the third chapter, there is a serious argument that SRM should be treated as a public good and several models of public engagement are treated in the literature. The Oxford principles are precisely emphasising this aspect.

It could be easily seen that this argument self-imposes itself in the Rawlsian view. For, in Rawls, justice is ensured by strictly abiding by the rules of procedure *agreed* upon in the original position by the contracting parties. In the case of climate engineering it can be seen that there can be no agreement upon the rules without engaging all the parties who are involved in it. Without accommodating the views and concerns of all parties who are directly or indirectly affected by climate engineering there can be no fair rules of procedure. Without fair rules of procedure there is no just result. Therefore, from the Rawlsian point of view, engaging the public and adapting an inclusive approach in the deliberative phase is vital for procedural justice in climate engineering. This idea is dormant in Rawls's formulation though he does not have climate engineering in mind here: "A fair distribution can be arrived at only by the actual working of a fair social process over time in the course of which, in accordance with *publicly announced* (emphasis added) rules, entitlements are earned and honored. These features define pure procedural justice."[94] Further, Rawls says, "Now a social contract is a hypothetical agreement a) between *all rather than some members of society*,(emphasis added) and it is b) between them as members of society (as citizens) and not as individuals who hold some particular position or role within it."[95]

6.4.7Conditions for Climate Engineering to Comply with Procedural Justice

Since details are unnecessary for pure procedural justice in the Rawlsian sense, we can conceive only general procedural assumptions at the moment. From the above discussion, summarily, we can identify some such general assumptions that are essential to guide our procedures that would bring us somewhat close –not fully satisfying - to the ideal of pure procedural justice in climate engineering.

[93] Rawls, *Political Liberalism*, pp. 68–69.
[94] Rawls, *Political Liberalism*, p. 282.
[95] Rawls, *Political Liberalism*, p. 258.

1. Although climate engineering may be justified from the viewpoint of the end-result of the procedural justice in Rawls, it is doubtful whether all just procedures can be in place as to ensure a just outcome. Although there are some positive streams, the nature of the climatic deliberations today is far from any promising consensus with normative and legal force. In today's 'de-globalizing' world of 'post-truth,' it may be more romantic than rational to hope so. Therefore, the fairness of procedure in Rawls cannot be complete unless the pre-geoengineering agreement carries the provisions for post-deployment procedures that any degree of unfairness or injustice due to unforeseen consequence will be addressed by a fresh agreement drawn in the same way as though they were deliberating for a consensus under a Rawlsian veil of ignorance.
2. It may be an added impetus for proponents of climate engineering if they can present a convincing scenario, after the model of the Rawlsian scheme, that climate engineering will be developed only on a platform from which all climatic injustice is uprooted and climate engineering further consolidates and enhances this new found system of climatic justice. Climate engineering procedures should assure that the Rawlsian principles of equal liberty, fair equality of opportunity and difference principle are well intact. Therefore, ethical justifications for climate engineering have to be directed adequately to identifying the promising tracks of justice in climate engineering. Put simply, it is a substantive requirement of procedural justice that (at least in the Rawlsian scheme) there is no isolated treatment of the justice of climate engineering apart from the justice of climate change at large.
3. Since the redress of the present climatic injustice is impossible without change of life-style – a consequent imperative from mitigation strategies -, it becomes clear that procedurally it is irrational to assume that climate engineering alone suffices to tackle the environmental social, and political challenges of climate change. It questions the claims of the hardcore exponents that climate engineering can be treated as 'Plan A.' Procedurally climate engineering can be treated at best as 'last resort'option.

6.5 Recommendations

In the light of the dialogue between the Rawlsian view of pure procedural justice and climate engineering we will make the following recommendations that are indispensable to make them somewhat compatible.

1. Procedural fairness implied the necessity of treating climate engineering as a public good. The emphasis on climate engineering as a public good sets limits and conditions upon the extent the private stakeholders can be involved. Rawls's assumption that "... fair bets are those having a zero expectation of gain..." gain currency in the climate engineering context. As a research enterprise, climate engineering will require unprecedented levels of purity of intention with a global outlook and determined focus, freed from every commercial interest. The propriety of the usual procedure of investing into research, developing, patenting and selling for profit will not be compatible with the extreme sanctity of procedure required for ensuring just results out of pure procedures. It is out of question to leave the development of the technology to the dynamics of the free-market driven by competition and profit motives. The interests of the global public and the interests of a healthy climate should be the primary motivations for the project. The remarks of Rawls does hold directly for climate engineering: "In pure procedural justice, then, distributions of advantages are not appraised in the first instance by confronting a stock of benefits available with given desires and needs of known individuals. The allotment of the items produced takes place in accordance with the public system of rules, and this system determines what is produced, how much is produced, and by what means."[96]
2. Fairness of procedures alone leads to just results in the absence of any independent criterion of specific methods. Conversely, the scope of diverting the technology for military intentions should be absolutely nil in climate engineering. The result of a military benefit means an unjust result which points pre-emptively to an unfair procedure. Climate engineering consensus has the precise objective of a healthy climate and military misuses are largely counterproductive to this objective. The governance mechanism for climate engineering should take every precaution against any misuse of technology along the military lines.
3. Since climate engineering is to be treated as a public good, it is necessary for procedural justice, that the public be adequately informed and engaged beginning with the early stages of its developments. Complete transparency of the entire procedures in the research and development should be ensured. Since the debate is still confined to the academic and scientific circles, it should be an immediate priority to take the debate to the general public through well-designed campaigns. The SRMGI (Solar

[96] Rawls, *Theory of Justice*, p. 76.

Radiation Management Governance Initiative) has underscored this aspect of treating SRM as a public good and therefore obtaining the consent of the public. "[T]hose responsible for overseeing the research need to make every effort to ensure that the public understands and agrees that it wants to pursue this option, and is consulted as inclusively as possible in decision-making processes throughout any research programme."[97]

4. As more information will be poured into due to developments in environmental and other related branches of science, climate engineering field tests, etc., the decision to develop climate engineering could be subjected to periodical review. The parties in agreement should be free to withdraw their consent at any point of the research if subsequent information shows that the technology is likely to affect the party adversely. As the parties enter into agreement in fair and free conditions,[98]the fairness of the terms of the agreement will be such that they can pull themselves out at any phase of the research and development.
5. One of the most prominent concerns with procedural justice in climate engineering raised by most authors is the possibility of unilateral deployment of climate engineering by any one individual nation. The scope for the unilateral deployment by individual nations is altogether ruled out from the Rawlsian point of view. For, in the Rawlsian scheme, the contracting parties are to agree upon the terms in the original position. Now, in the original position, the contracting parties do not know to which nation they belong or to which generation they would belong. When they find that there will be parties who would be significantly suffering from the blunt of the unilateral deployment of any other party and the accompanying fear of the possibility of any party becoming one such suffering party, rationally conceived, all parties are likely to agree upon a term that would prohibit any unilateral deployment of climate engineering resulting in unilateral loss to any other party. The governance mechanism for climate engineering should be such that the issue of unilateral deployment should be ruled out at the outset and the very scope for the same should be eliminated.
6. Adherence to the Rawlsian pure procedural justice logically invalidates the fears that research and development will naturally lead to deployment – a major contention against research and development. If the procedures are fair and complete, there is no question of deployment unless for necessity, not for anything that is short of just

[97] SRMGI 2011, p. 22.
[98] Rawls, *Theory of Justice*, p. 75.

results, let alone for luxury or fun. Ensuring proper procedures imply that there is no provision for any illegitimate deployment. Leaving any such scope open means that the procedures followed are far from being fair and complete. That there is such a reasonable apprehension about research and development point to the extent of homework that remains to be done even before research and development. Our recommendation is that just as unilateral deployment needs to be avoided, so too the slippery slope towards deployment following research and development should also be checked by means of clear governance rules.

7. Involving climate scientists, social scientists and ethicists from the populations and countries vulnerable to climate engineering not only in policy making and ethical deliberations, but in the very research and development of the technology is mandatory. It should be done from the early phase of the research. As of now, most climate engineering scientists are from the rich countries and their *Sitz im Leben* may act as a barrier in fully anticipating or appreciating the concerns of the vulnerable population. From the Rawlsian viewpoint of procedural justice, it is not enough to treat the vulnerable population as honorary members to the debate, rather they are to be given privileged, substantive, and decisive status in the decision making process. As Preston has observed, "Yet of all the populations that should participate in the early days SRM research, it would appear that the most vulnerable populations in the poorest countries are uniquely deserving."[99]
8. Control of technology is a decisive factor in defining liberty and opportunity. Equal liberty and fair equality of opportunity - background conditions for pure procedural justice – cannot be met without equal access to and equal control over the climate engineering technology. Without the sharing of technology among parties, parties in the contract do not do the deliberations as equals. As the concept and development of the climate engineering technology is concentrated in the hands of the developed countries, just procedure will demand that the countries, which are unable to develop the technology, should have access to the technology. The countries that are likely to be hit by the technology are to be involved from the early phases of developing the technology. The interests of the poor countries, if adequately represented from the beginning, can influence the nature, course, and the choice of options in technology. However, as we have seen that unilateral deployment will be tantamount to unfair

[99] Preston, *Engineering the Climate*, p. 88.

procedure, transfer of technology cannot be treated as a licence to unilateral deployment. The Rawlsian observation bears direct implications for climate engineering: "[I]nstitutions must, from the outset, put in the hands of citizens generally, and not only of a few, sufficient productive means for them to be fully cooperating members of society on a footing of equality. Among these means is human as well as real capital, that is, knowledge and an understanding of institutions, educated abilities, and trained skills. Only in this way can the basic structure realize pure background procedural justice..."[100]Though not in the climate engineering perspective, UNFCCC has emphasised this aspect by asking the signatories to "... promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases."[101]

9. Our analysis shows that the need for political determination and goodwill emphasised by several ethicists are not wishful prayers, but genuine or perhaps the only way to address the problem at a radical level. Deliberations by rational but self-interested parties in a hypothetical setting show that it is rationally necessary to redefine our self-interest in order to be procedurally fair with climate engineering. Putting it differently, much of the self-interest of many individual nations protected at international climate change forums is not holding up rationally. Today part of the challenges with climate change summits is that the parties are doing negotiations as US-Americans, Germans, Chinese or Indians who have self-interests to protect. The Rawlsian scheme shows that unprecedented levels of dissociation from national interest and recourse to conservative solutions like change of life-style will be needed to ensure justice in climate change climate engineering. Change of life-style demanded by mitigation is not a charity but a rational obligation. In an emerging world of 'surrealism' where populism and nationalism is on the rise, fair procedures of just climate engineering demands a radically different mind-set soliciting relaxed migration rules, sharing of potential losses irrespective of national differences, reformulation of the existing legal frameworks like CBD, ENMOD and UNFCCC and formulation of new legal frameworks that justly engages the present climatic injustice as well, privileged consideration of applications for funding the research by the poor countries, and mandating the representation of the poor and the potentially vulnerable

[100] Rawls, *Justice as Fairness*, p. 140.
[101] *UNFCC* 1992, p. 5.

countries in funding forums, etc. Conversely, the argument of some of the proponents that climate engineering provides a magic bullet to get rid of conservative solutions like changing our life-styles do not withstand the test of rational scrutiny.

10. The priorities and emphases for future course of development as reflected in the present debate needs to be reconsidered. While the predominant thinking in the literature is to place the trust in the governance mechanism to ensure fairness and justice, in the Rawlsian scheme, governance rules are only part of the fair procedures that lead to just results. In other words systemic fairness in procedures subsumes just governance. It should be seen that in the Rawlsian four stage sequence of the formation of the contract,[102] governance and administration comes only at the final stage. Without belittling the importance of governance, more preliminary and foundational concerns are also to be prioritized.

6.6 Conclusion

In sequence to the investigation of the compatibility of climate engineering with the distributive and intergenerational justice in the preceding chapters, this chapter analysed the compatibility of the same from the viewpoint of procedural justice. The first part on literature review assembled the scattered elements of the procedural issues in climate engineering. The second part narrated the Rawlsian view of procedural justice dwelling mostly on the categories of procedural justice - especially pure procedural justice -, background pure procedural justice, and relation between procedural justice and distributive justice. In the third part, we approached the lead question of the compatibility of climate engineering with justice using the theoretical frame of the Rawlsian pure procedural justice that led us to make some concrete recommendations in the fourth part.

Our analysis shows that the complexity and radicality of the concerns with procedural justice in climate engineering and the unpreparedness of the scientific and ethical community as of now do not offer sufficient justification for climate engineering. It is found that despite the serious concerns about its viability, the Rawlsian scheme offers, perhaps the most radical and the most demanding standards for perfect fairness and propriety of procedures to ensure justice in climate engineering. The intricacies of the procedural justice in climate engineering are substantively intertwined with the larger issues of climatic justice altogether and calls for

[102] See, Footnote no. 44 in this chapter.

concrete and determined practical exercises to translate the warranted fairness and justice into the course of development of the climate engineering technology. Our analysis, while exposing the flaws in our preparedness, also suggests essential directions to advance the debate to stand up to the hard demands of procedural justice. We wonder if Rawls had climate engineering in mind when he wrote, “Granting that existing conditions always fall short of the ideal assumptions, we have some notion of what is just. Moreover we are in a better position to assess how serious the existing imperfections are and to decide upon the best way to approximate the ideal.”[103]

In the preceding three normative chapters we have been trying to answer the research question can climate engineeringbe developed in a just manner compatible with the Rawlsian principles of distributive, intergenerational and procedural justice. Now it is time to stay back, evaluate and consolidate the responses and perspectives emerging from our analysis and findings. That defines the objective of the concluding chapter that follows.

[103] Rawls, *Theory of Justice,* p. 272.

Chapter 7

Conclusion: Retrospective and Prospective Perspectives

7.1 Introduction

Having looked at the concerns with justice from the Rawlsian point of view in the preceding chapters, in this chapter we will revisit our research question and see summarily the answers emerging from the analysis. We will also see how our position is vindicated against certain other positions. We will highlight the uniqueness and relevance of this research and suggest certain directions for future research in relation to justice in particular and ethics in general in climate engineering. With this objective, in the first part of this chapter we see retrospectively how our research question is answered and the second part will highlight the unique dynamics of this research. Finally we offer some conceptual and theoretical outlooks for the future directions of research.

7.2 Revisiting the Research Question

Aristotle, true to his rationalistic mindset, emphasised accuracy and exactitude particularly in mathematics. "[I]t is ... foolish to accept probable reasoning from a mathematician..."[1] However, epistemological developments even in physical and mathematical sciences have advanced far beyond what Aristotle could envisage, to the levels of indeterminacy and probability. It was Einstein who said that "As far as the laws of mathematics refer to reality, they are not certain; as far as they are certain, they do not refer to reality."[2]Austrian logician and mathematician Kurt Gödel showed that there are propositions that are true but not provable.[3] Similarly in philosophy, we have Wittgenstein who coined a similar paradoxical statement, "Most of the propositions and questions to be found in philosophical works are *not false but nonsensical*."[4] Our recourse to these seemingly strange metaphors is to highlight an intrinsic limit in formulating a definitive response in yes or no to

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[1] Aristotle, *Nicomachean Ethics* Book 1, Section 3.
[2] Speech of Albert Einstein cited in Fritjof Capra, *The Tao of Physics*, 2nd, ed. (New York: Bantam Books, 1984), p. 27.
[3] In the 1930s, Gödel proved a couple of revolutionary mathematical theorems, now known as *Gödel's incompleteness theorems*. According to the first theorem any consistent axiomatic system will have true sentences that are not provable in the system itself. It renders an axiomatic formalized consistent system incomplete. Ernest Nagel and James R. Newman, *Gödel's Proof* (London: Routledge, 2002).
[4] Ludwig Wittgenstein, *Tractatus Logico-Philosophicus*, Translated by D. F. Pears and B. F. McGuinness (New York: Humanities Press, 1961), 4.003.

our research question –can climate engineering be developed and deployed in a just manner fulfilling the conditions of distributive, intergenerational and procedural justice under the Rawlsian scheme? The enormous complexity of the debate landscape of climate engineering coupled with the characteristic features of a reflective and speculative discipline like ethics, our moral deliberations on the justifiability of climate engineering from the viewpoint of justice remain provisional, far from being final and definitive. Our caution against oversimplification desist us from making categorical responses in the affirmative or in the negative. Gardiner's response four years ago to the question of whether he is for climate engineering that such a question is an "unhelpful distraction"[5] seems to be holding still. A definitive statement on the justifiability of climate engineering from the point of view justice is premature mainly due to insufficient scientific data.

Summarily, our response to the research question can be articulated in answering the following questions:

1. Is climate engineering more a challenge or an opportunity for justice?
2. If it is more a challenge, are the challenges surmountable before and after the deployment of the technology?

Answering to the first question, our analysis implies that in the current phase of the debate, climate engineering is far short of substance as a policy to be accountable to the normative demands of justice in the three counts of distributive, intergenerational and procedural justice.

The bottom-line of our analysis of the *distributive justice* showed that there will be winners and losers in climate engineering. Relying on simulation studies against the Rawlsian scheme, we showed in chapter 4[6] while dealing with distributive justice that deployment of climate engineering is poised to go against equal rights to the most extensive scheme of equal basic liberties compatible with a similar scheme of liberties for others. Despite the elements of uncertainty in regard to the impact of climate engineering, as discussed in chapter 4,[7]the simulation studies show that the impact of climate engineering, especially of SRM, will be unevenly distributed. Simulation studies show disturbing results that differentiated spatial changes in precipitation can hit regions like Africa, South America, and South-Eastern Asia

[5] Gardiner 2013b, p. 28.
[6] See Chapter 4, 4.4.1.
[7] See Chapter 4, 4.4.1 & 4.4.2.

most. Available data undisputedly show that SRM and distributive justice are very much incompatible. The results of the studies suggest that the various aspects of injustice related to climate change to which the global poor are already exposed are likely to be compounded by climate engineering.[8]Climate engineering will surely violate the principle of equal liberty, the difference principle and the principle of efficiency – in the Rawlsian scheme. And the current phase of the debate does not show any serious attempt to practically engage the challenges that are certain to distributive justice. It is here that our analysis is forced to condone climate engineering to be incompatible with distributive justice.

The case with *intergenerational justice* too is not anything as promising as to present climate engineering as an opportunity. The issue of sudden termination limits the liberty of the future generations. The realization of just institutions is necessary for intergenerational justice under the Rawlsian scheme. Deploying climate engineering means the primary natural good of a sustainable environment will ever be technology-dependent. Therefore, it cannot be claimed that just institutions will be established in the future. An option for a technical fix over a fundamental solution like change of life-style will earmark the present generation as ungrateful receivers or as selfish takers, instead of being responsible givers. Our analysis showed that a just concern for future generations will primarily eliminate the context of having to make a choice between mitigation and climate engineering by avoiding circumstances that create dangerous climatic conditions that warrant climate engineering. Accordingly it has been seen that much impetus for climate engineering is possibly drawn from the "generational selfishness"[9] of the present generation as it looks at climate change from its relative temporal position.

In regard to *procedural justice* too, the odds are much against any easy rapprochement between climate engineering and justice. Although the Rawlsian dictum that a purely fair procedure ensures just results is fully acceptable, its effective application to climate engineering is doubtful. Thus in all three counts of justice, in our analysis, given the present context of the world, climate engineering is more of a challenge to justice than an opportunity.

This position in itself does not invalidate the desirability of the climate engineering project. We have also seen that if a purely fair procedure can be in place, it makes climate

[8] See Preston 2014, p. 28; Shue 1992.
[9] To use Burns' phrase; Burns 2013, p. 220.

engineering as a watershed opportunity not only for environmental justice but also to rectify the climatic injustice prevalent in the present world at large. Such a fundamental fixation with fair procedures will in principle eliminate the apprehensions we shared about distributive justice and intergenerational justice. That is to say, if all fair procedures are well in place, there is no challenge from climate engineering to distributive and intergenerational justice.

This observation brings us to the second question that we posed above, are the challenges to climate engineering from justice surmountable before and after the deployment of the technology? Exactly, this is the issue that the lead questions - what are the conditions under which climate engineering may be justified from the point of view of distributive, intergenerational and procedural justice in the Rawlsian scheme? – of our three justice chapters try to answer. Climate engineering can be an ambitious project if it can meet the radical challenges and the stringent conditions under which it may be justified from the justice point of view. We saw that such an ideal state of affairs, though hard to achieve, has the potential to alleviate the climatic injustice presently prevalent between nations.

Establishing proper governance mechanism with a decisive role assigned to the representatives of the vulnerable populations, detailed provisions for compensation to the victims, facilitating reliable forecast and contingency plans, creating provisions for adaptation for those who will be affected, relaxed migration policies towards the victims, and specific research agenda targeting the vulnerable are some conditions recommended for ensuring distributive justice. A deliberate saving mechanism for future, forming clarity and binding terms for compensation in regard to the rate, beneficiaries and duration, framing new legal frameworks and amending international treaties such as ENMOD, CBD, and UNFCCC, are some conditions necessary for just climate engineering from the point of view of intergenerational justice. Insulating technology against military intentions and profit motives, treating the technology as a public good, universal consent, addressing the prevalent climatic injustice across the globe, ban on unilateral deployment, transparency in procedures, provisions for transfer of technology to the poor nations, etc., are the major conditions found essential to make climate engineering as much an exercise from the point of view of procedural justice under the Rawlsian scheme. Among these, the condition of eradicating the climatic injustice existing in the world today – a logical imperative from the Rawlsian scheme – is perhaps the most radical of all that is hard to achieve. That is to say, the challenges to justice from climate engineering are surmountable provided we employ unprecedented levels of political determination and goodwill, international collaboration and the existential readiness to embrace conservative ways to alter individual life-style. Ironically, the demands are such that it may require harder measures to ensure justice in climate engineering than achieving the same targets set by the mitigation strategies. If humanity can exhibit such extraordinary courage to stand up to the test of the times, the success with mitigation may acquit us from having to geoengineer at all.

We do not overlook positive testimonies to what political determination can achieve in this regard. The unprecedented levels of consensus and willingness shown by the Paris summit stand tall among these. There are also promising reports along the line that despite the rollback on the US climate policy, China and India are set to overachieve the targets set in the Paris Agreement. The report released at the UN climate meeting in Germany estimated that given the present rate of decline in coal consumption China will achieve its target ahead of schedule and India will achieve a 40% reduction in emission from coal by 2022.[10] It is hoped that these developments can potentially outweigh the adverse impact of the recent US rollback.

7.3 Some Pragmatic Considerations

Viewing our approach to justice from a more pragmatic stream of thought may exhibit the limits of our consideration of climate engineering in general and call for taking region-specific and country-specific approaches. We cannot fail to see the situations where miscarriage of justice will be implied to particular nations unless climate engineering is exercised. That may set the agenda for another important stream of research in the field. From the justice point of view, there could arise circumstances where outright negation of climate engineering could lead to negation of justice to the poor and the populations vulnerable to climate change, where climate engineering may be inevitable, for instance, the possible context of the earth crossing another tipping point. That dangerous climate change has already occurred and assuming that the efforts at mitigation are nowhere to achieve their target and there is no adequate aid for adaptation, the island nations in the Pacific and the Indian Ocean are confronted with an imminent do or drown situation due to rising sea levels. If they find that they will manage to borrow some breathing space through climate engineering, not allowing them to geoengineer in such a context for reasons of its global impact or unforeseen consequences would be tantamount to compound injustice to the

[10] Climate Action Tracker, China, India slow global emissions growth, Trump's policies will flatten US emissions. 15th May 2017. Available at http://climateactiontracker.org/news/278/China-India-slow-global-emissions-growth-Trumps-polices-will-flatten-US-emissions.html. Accessed July 1, 2017.

peoples of such nations, primarily, because injustice has been meted out to them by subjecting them to the dangers of anthropogenic climate change and in not helping them adequately with adaptation and secondarily by depriving them of their last resort option for survival. There may be circumstances in future where outright negation of climate engineering may run contrary to rational solutions. Preston's (2011) question, what if climate engineering were to be used for averting a dangerous climate change not caused by anthropogenic factors,[11] does deserve a meritorious treatment. The question of Burns et al., "if another ice-age is in the offing will climate engineering of a different sort be required?"[12]suggests possible contexts where climate engineering may be a "responsible obligation"[13] from the justice point of view as well.

As we have seen in Chapter 3, Gardiner (2013c) has objected to this strand of thought, which in the debate is often referred to as the desperate argument.[14]According to Gardiner (2013c), the desperate argument is a false self-defence not engaging the factors that led to the desperate situation in the first place. We can agree with the point of the argument, but we cannot confuse between the ideal and the practical; between rational analysis and intuitive response. Responsive action inbuilt in our ethical phronesis is provoked by the immediacies and intuitions irrespective of the causal factors that may force a thinking otherwise. When confronted with a demanding situation of life and death, we do not go to explore the root cause, rather to provide the actions that are deemed necessary to avoid catastrophe and facilitate life. For instance, on the road we find a reckless rider knocked down against a median and is crying for life support. Our immediate intuition is to rush him to the hospital without investigating as to what led to the accident. Even if we knew that his rash ride has been responsible for his accident, our ethical intuition can supersede and subdue several of the extraneous factors that can limit the degree of our rational responsiveness. The Levinasian metaphor of the face as the epiphany of the other stimulating action[15] does attribute some weight to pragmatic considerations in climate engineering deliberations, perhaps overstated

[11]Preston 2011, p. 471.
[12] Burns 2013, p. 142.
[13] Phrase is of Preston. See, Preston 2013, p. 27
[14] See Gardiner 2013b.
[15] "The face of the Other at each moment destroys and overflows the plastic image it leaves me, the idea existing to my own measure. . . . It expresses itself." Emmanuel Levinas, *Totality and Infinity* (Pittsburgh, PA: Duquesne University Press, 1969), pp. 50-51

by Michaelson, for whom "... the right thing exists in the mind. Climate change is in the atmosphere."[16]

The proponents modifying their light-hearted approach to the risks and reinstating their commitment to mitigation and the hard-core opponents giving up their treatment as an intrinsic evil may offer more responsible pathways for the debate to advance forward. The metaphor "rethinking the unthinkable"[17] may be relevant in regard to concerns with justice as well. Though Preston (2011) considers the entire climate engineering to be a sort of lesser evil, at the end of day, we could see that under certain circumstances, certain forms of CDR may turn out to be a lesser evil."An accounting that was global in scale, intergenerational in nature, projecting many centuries into the future, and ranging across both human and environmental well-being would present insurmountable technical problems. However, there is nothing theoretically at odds with the idea that geoengineering could, at the end of the day, remain the lesser evil."[18]

7.4 The Conceptual Recommendations of the Research

Below we present what we consider to be some foundationalrecommendations emerging from the research at hand upon climate engineering ethics in general and justice in particular.

7.4.1 The Rawlsian Scheme and Beyond Rawls

Conceptually and strategically, perhaps the major stream of engagement in this research is the application of the Rawlsian principles of distributive, intergenerational and procedural justice to the climate engineering debate. The Rawlsian strand of the research is found to be rich with conceptual resources and normative tools to significantly inform and advance the overall climate engineering debate.

For Rawls, ethics pertains to the basic structure of the society, as the contractual tradition represented and advanced by him is founded on the pristinely ideal and the perfectly non-circumstantial state of affairs as the conditions for forming the agreement between the contracting parties. In the climate engineering context, Rawls is useful to go to the root of the issue. As the issues of climate change and responses like climate engineering basically stem

[16] Michaelson 2013, p. 107.
[17] See, Preston 2011.
[18] Preston 2011, p. 468.

from the anomalies in the basic structures of the society such as patterns of distribution and consumption, constitutional and legal systems, economic policies, etc., Rawls cautions us on the gravity, complexity and radicality of the homework that needs to be done to be prepared for climate engineering to be deployed in a fair and just manner. From the point of view of the Rawlsian justice a radical and sustainable response to dangerous climate change is not as simple as a policy decision on balancing the CO_2 concentration in the atmosphere. It needs radical restructuring of our existing practices and ways of life, redefining the ratios of distribution, rethinking on our worldviews, and redressing the geographical bad luck of several of the populations. It is from Rawls that we realize that justice in climate engineering reasonably needs primarily a consolidation of environmental justice at large.

The emergence of Rawls on the scene exposes the conceptual poverty of certain superficial responses to climate change. In climatic negotiations, eliminating subjective reservations under a cloud of wishful ignorance about the wider issues requires absolute purity of intention and perfect objectivity for climatic policies freed from national, geographical and temporal partisanship that limit the horizons of our ecological vision. Herein resides the uniqueness of Rawls's original position for climate change negotiations particularly for climate engineering. No artificial patchworks can withstand the pristine rational objectivity of a hypothetical original position. Climate engineering does benefit from Rawls to shed off the criticism against it as a symptomatic approach by restoring some conceptual depth and thereby helping it to address the root of the problems with climate change.

Climate engineering for mere pragmatic reasons may finally end up as a compounded problem rather than a solution. What the Rawlsian scheme shows is the primacy of genuine philosophical motivations and nonpartisan conditions devoid of hidden agenda and petty political interests. To use a common sense analogy, we will treat a patient for lung cancer caused by habitual smoking. While medicine may go all out with trying approaches like surgery, radiation, and chemo, it cannot be assumed that the patient can continue with his smoking. As the burden of proof now rests with the proponents, it is unto them to convince others that they are not content with a short-sighted pragmatic justification, rather prepared to address the issue systemically.

The Rawlsian preoccupation with the basic structure of the society presents an ideal state of affairs whereby climate engineering, if the conditions of justice are met, may even be preferred over mitigation as it is deemed to fix the existing injustice with climate change. Though the Rawlsian scheme has its limitations, it may be better than many other theoretical frameworks to be used in the context of climate engineering. As Rawls states on one occasion: "Justice as fairness will prove a worthwhile theory if it defines the range of justice more in accordance with our considered judgments than do existing theories, and if it singles out with greater sharpness the graver wrongs a society should avoid."[19]

While we appreciate the theoretical merits of Rawls, recognition of the limits of our research imposed by our methodic fixation with the Rawlsian scheme can equally propel the maturation of the overall debate. Rawls's theoretical preoccupation with the basic structure of the society has unwittingly obscured our attention from treating some of the down to earth considerations in environmental justice like sustainable development, sovereignty and self-determination of nations and individuals, the issues of human rights and the rights of the non--human, cultural and environmental self-determination, quality environment and quality health care, etc., that are crucial for justice in climate engineering as well. Hence this research needs to be complimented by and completed by an analysis of the issues of justice against other useful theoretical models too.

While Rawls stands for the present time entry interpretation of the original position, our present time entry carries extremely lethargic factors against the ambitious designs of justice. While some authors in biology and neuroscience have the sunny optimism of "altruism genes" and "mirror neurons,"[20] what we find in reality is the return of the "selfish gene"[21] in a de-globalizing world of post-truth, be it the cases of Brexit in Europe or Trumpism in the US or the emerging right-wing populism elsewhere. The recent US U-turn with its environmental policy invoked the negative paradox of solving the problem by negating its existence. The Rawlsian ideal of a rational foundation for fairness and justice in practice is still far from transcending the intrinsic traits of selfishness in biological evolution. It looks as if the Rawlsian perspectives are intact and ideally safe mainly under a veil of ignorance and the reality test presents a far more insecure scenario.

The international aid in response to the natural disaster of tsunami in 2004 has positively testified to the charity of humanity. The silent and prolonged disaster like the dangerous climate change and the lack of international goodwill and political determination

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[19] *Theory of Justice*, p. 176.
[20] See Chapter 5, 5.4.3.2.
[21] See, Richard Dawkins, *Selfish Gene* (Oxford: Oxford University Press, 1976).

to ensure justice in the face of ecological disasters carry the negative certification that humanity has not transcended the level of charity to affirming justice in terms of fundamental rights, global responsibilities and moral obligations. Mere charity will not suffice to ensure justice against the global consequences of climate engineering that is sure to produce ecological refugees and raise serious challenges to fundamental human rights. It needs firm commitment to affirming and respecting the universal human rights against every odds, foreseen and unforeseen, protected and sustained by universal legal regimes.

Our lamentations on the negative cultural traits are to show that justice in climate engineering in reality has to encounter the psychological and cultural lethargies of the present time as the entry point of interpretation. We mean to say that consideration of whatever practical issues we did not consider in our research question is likely to make the challenges to justice harder for climate engineering than what is highlighted by the Rawlsian perspectives.

7.4.2 Dispelling the Fragmentary and Restoring the Systemic

Climate change and the responses to it are very complex issues with overlapping political, geographical, legal, technological and existential aspects. Among the present responses, neither mitigation nor climate engineering seem to have absorbed the complexity in its totality and are often dominated by pragmatic considerations, although there are several alarms sent by the advocates of environmental philosophy and ecological ethics. Our research can be an added conceptual tool to widen the horizons of appropriating the responses to climate change, particularly of climate engineering. The pragmatic approach treats the problems in isolation with a methodic style of picking and choosing. An analysis from the perspective of justice, particularly informed by the Rawlsian scheme, warrants a more systemic approach to identify the problems in their social, political, economic and ecological embeddedness.

Firstly, justice perspectives provide a vantage point to partly refute, substantiate, revise or reorder some of the leading arguments for and against climate engineering. For instance, the feasibility arguments for climate engineering had the flowery rhetoric of the incredible economics of climate engineering considering only the cost of development and deployment of the technology, completely ignoring the indirect expenses pertaining to risky side-effects, compensation, rehabilitation of the displaced, and so on. Our analysis has shown that there can be no just climate engineering assuming such blissful ignorance of the wider issues.

Secondly, the discard of ethics in general and justice in particular, particularly by the champions of technology, is proven to be naively reductionistic. The legitimacy of sweeping simplifications like the comment of Lane that “moralistic objections are likely to have only limited effect”[22] is challenged outright by the perspectives provided in this study. It is interesting to note that in the process of the maturation of the debate, some of the initial hardcore proponents of climate engineering now have opted for a moderate position, as epitomised in Michaelson who described climate engineering to be a magic bullet in 1998and a lesser evilin2013.[23]

Thirdly, the lesser evil argument in support of climate engineering, when viewed from the justice perspective, loses some of its currency as we find that climate engineering will necessarily create winners and losers, and what is presumptuously termed as lesser evil may turn out to be a greater evil for some populations, if a case-specific or nation specific analysis of the concerns with justice is made. Though we may be compelled to agree with many apprehensive conclusions that at the end of the day, it may be the lesser of the two evils, we have to humbly acknowledge that the lesser evil position reflects our philosophical and moral bankruptcy and our preference for the simple and the pragmatic over the fundamental and the conservative.

Fourthly, looking at the climate emergency arguments for climate engineering as to buy time for mitigation, we cannot fail to see situations where climate engineering projects may even curtail the available time in an otherwise non-geoengineered world for the survival of certain populations. For example, one of the worst fears about climate engineering is that it may even completely shut down the monsoon in Asia, particularly in India and Bangladesh. With about 70% of the rural population in India relying solely on the annual monsoon for their yearly sustenance, a sudden termination of the monsoon could cause irreparable and irrevocable damage to billions in the subcontinent within a short span of time.

[22] Lee Lane, “Climate Engineering and the Anthroposcene Era,” in Will C. G. Burns and Andrew L. Strauss, Eds., *Climate Change Geoengineering – Philosophical Perspectives, Legal Issues and Governance Frameworks* (New York: Cambridge University Press, 2013), p. 144.
[23] See Michaelson 1998 and 2013.

Thus we confirm that anything less than a paramount attention to the concerns with justice will not suffice to justify climate engineering. Justice perspectives book us against any artificial conduits within the rhetoric for climate engineering.

7.4.3 Correcting and Consolidating the Prevalent Assumptions

On the one hand we havehighlighted the need for correcting some of the dominant patterns of arguments in the climate engineering debate and on the other we have confirmed some other perspectives. For example, firstly as a corrective exercise, our research categorically rejects the idea that climate engineering can be considered as the Plan A to combat the dangers of climate change, a hubristic presupposition shared by several proponents especially in the early days. As the awareness of the side-effects and consequent challenges of justice become vivid such rhetoric does not pass the reality test. In our intersection between the Rawlsian scheme and various concerns with justice in climate engineering, on three occasions we have challenged the assumption that climate engineering as a Plan A is least compatible with distributive, intergenerational and procedural justice. It also answers the question that we found open ended in the review of the literature as to what is the moral value of climate engineering consideration in the debate, as a Plan A or Plan B. Justice perspectives inform the debate that climate engineering be treated only as a supplementary tool to mitigation failing which there is little scope to defend climate engineering as a just exercise.

Secondly, as a consolidating exercise, our research endorses the viewpoints of formal bodies like IPCC and Royal Society that preference should be given to CDR techniques to begin with research and development. A recurrent observation in our research was the disequilibrium between SRM and CDR on the debate scenario. The current debate is predominantly focussed on the ethical implications of SRM technologies with inadequate attention paid to the CDR schemes. It was the recommendation made by Royal Society and IPCC that CDR schemes are less prone to yield harmful and irrevocable side-effects. Conversely, this finding is upheld by our research that most challenges to distributive, intergenerational and procedural justice due to seen and unforeseen side-effects are posed by SRM, and CDR is relatively better off with managing the side-effects that threaten justice. Major challenges to distributive justice resulted from the side effects of SRM. The sudden termination effect is an exclusive threat from SRM to intergenerational justice. The possibility of compounding the present climatic justice is mostly due to SRM. While CDR is not fully risk-free, its risks seem to be somewhat more surmountable relative to SRM.As we observed elsewhere, the future course of the debate along the CDR line will contribute significantly towards the future dynamics of the debate.

7.5 Justice in Climate Engineering: Future Directions

7.5.1 The Nod for Research and Development

If the conditions for just climate engineering can be met and the challenges are surmountable, the nod for moderate research and development seems warranted at this point in the interest of justice mainly for two reasons. Firstly, to ensure justice at an otherwise no exit situation, and secondly, to ensure that as much homework is done for ensuring justice in an unavoidable circumstance of having to deploy climate engineering. What if mitigation fails and climate engineering not developed? The aftermath is unlikely to be as bad as the challenges to justice from climate engineering. Invoking climate engineering for other than anthropogenic reasons may enable better understanding. For instance, let us imagine what happens if a catastrophic solar maximum[24] is causing an abnormal rise in the global temperatures. Studies have shown that the solar minimum and the solar maximum can cause changes in regional weather patterns.[25] The dangers of anthropogenic climate change worsened by an abnormal solar maximum may become a justifying ground for a certain nation or nations to geoengineer temporarily failing which there can be serious injustice meted out to such populations. In terms of justice, though climate engineering does not enjoy the force and substance to be a formidable policy option as of now, there can be situations where outright negation of climate engineering can be equally detrimental to the cause of justice.

However, in the interest of justice the protocol for field research should keep it to the minimum level in the first phase with the objective to collect data and information. Ethical judgments cannot be done in a vacuum, and we need reliable and tangible scientific data to make fair ethical judgments. Conversely, as this objective of research does not imply the nod for development, which will be subject to approval or disapproval based on the feedback from the research, it avoids the slippery slope of the research leading to deployment. The objection of research funding being diverted cannot weigh against climate engineering as this is pertaining to the existential problem of the survival of the species[26] –a vital condition under

[24] Solar minima and maxima are the two extremes of the sun's 11-year activity cycle. At solar maximum, the sun with increased number of sunspots erupt solar flares into space. See, Wikipdedia, https://en.wikipedia.org/wiki/Solar_minimum. Accessed November 4, 2016.
[25] https://en.wikipedia.org/wiki/Solar_minimum. Accessed November 4, 2016
[26] See sections 3.3.1.1, 3.3.1.2, 5.2.1.3 and 6.4.4.

which climate engineering may be sanctioned in our analysis - that is formidable before any other research. Further, the sort of research and its governance as envisaged particularly by our analysis of the procedural justice ensures just background conditions and fair procedures for the research.

The involvement of the scientists from the nations that are supposedly vulnerable to the side-effects of climate engineering is to be ensured in the process of initiating research and development. For instance, greater involvement of scientists from India or Bangladesh in climate engineering researches since its early phase will result in a decisive attention paid to the impact of climate engineering on monsoon. As climate engineering is predicted to result in the partial or complete shutdown of the monsoon, it can aggravate the ill fate of the farmers in India and the surrounding countries. Given the present tragic fate of the farmers in India, it is very unlikely that Indian scientists will choose SRM schemes over CDR. The exposure of the Indian scientists to the harsh existential reality of over 12000 Indian farmers committing suicide yearly since 2013[27] is certain to influence the climate engineering policy of the country. These suicides are to a great extent caused by the impoverishment of the farmers due to the dangers of climate change. Any climate policy that may worsen the ill fate of the farmers is to be termed unjust in this context. Further, such concrete concerns will push to the fore with greater force the issues of harm and compensation. As for the future course of the debate, precise judgements on the justifiability of climate engineering will warrant more technology-specific, context-specific or even nation-specific analysis and assessment. While acknowledging the limitations of this research in this regard, it is proposed to be a proximate agenda for advancing the debate further along the line of justice.

It is to be recollected here that we have condemned partiality, national egoism, etc., only under the Rawlsian veil of ignorance. The main contention is that parties under the veil of ignorance are not likely to choose climate engineering at all. The point of our arguments is that the choice of technologies for the global climate engineering policy can be influenced by the regional scientists. The representing scientists from vulnerable regions and nations will be sensitive to the dangers from otherwise harmful technologies to their region. This sensitivity will influence their preferences in policy decisions as absolute value-neutral judgements may be rare.

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[27]Dhananjay Mahapatra, "Over 12,000 farmer suicides per year, Centre tells Supreme Court," *Times of India*, May 13, 2017. Available at http://timesofindia.indiatimes.com/india/over-12000-farmer-suicides-per-year-centre-tells-supreme-court/articleshow/58486441.cms. Accessed July 1, 2017.

7.5.2 Technology-specific and Context-specific Research Agenda

This research confirms the problematic outlined by many commentators on the ethics of climate engineering that the issue of framing and branding climate engineering is complex and complicated. Betz and Cacean (2012) had this observation as the predominant outcome of their review. It is our contention too that debate in the initial phase was more rhetoric than realistic, which led many proponents to go for hubristic technical nomenclature, which was to confuse and mislead the public and unwittingly invoking awful dissent. As we already observed in Chapter 3, even the strong proponents of climate engineering are now championing the rechristening of the technology to climate modification abandoning climate engineering.

What does the framing issue suggest to the concerns with justice? Any formulation that climate engineering can be just or unjust is vulnerable to the pitfalls of this framing problematic as any general formulation will miss precision and clarity as to which form of climate engineering may be just or unjust. So too, when we lay the conditions for ensuring justice in climate engineering, precision analysis will deem to correlate specific conditions with specific forms of the climate engineering technology. Intersecting justice with a generic nomenclature like climate engineering seems to imply uncritical generalisation that may not be helpful always. For instance, when Russia stands to gain a little from global warming and the Maldives stand to lose everything to global warming, permitting or not permitting climate engineering is intrinsically contradictory from the justice viewpoint. Ethical deliberations will be sufficiently fair if the contextual embeddedness of the issues is sufficiently regarded. An abstract generalisation of the limits of the desperate arguments does not rule out the desperate call and urgency for climate engineering in their contextual diversity. The whole of desperate argument may be differently conceived if the Asia-Pacific scientists or ethicists were to dominate the debate. For example, the debate on climate engineering as a potential 'moral hazard' to mitigation in the Western setting may be treated as a potential 'moral impetus' to mitigation in the Asia-Pacific context. For, the greater concern for the drastic consequences of climate engineering which may more adversely affect some nations, may force them to accelerate their attempts at the less demanding mitigation strategies.

A recent report of the Imperial College London in regard to the remote impacts of climate change may be a potential indicator to the unjust impact of climate engineering. Scientists at the Imperial College London calculated the drastic impact of the emission of sulphur dioxide in Europe upon rainfall in India.[28] It was found that one of the worst droughts that hit India in 2000 was caused by the pollution from the Industries in Europe. Sulphur dioxide emission of Europe caused acid rain, diseases of heart and lung, and severe damage to the growth of plants. It affected over 130 million people. According to their calculations, the emissions from the main industrial areas of the Northern hemisphere resulted in a reduction of about 40% precipitation on the North-West India. The remarks of Apostolos Voulgarakis, of the Imperial College, that "their research, along with other studies, showed the kind of problems that might result from attempts to use sulphur dioxide in a geo-engineering scheme,"[29] do share the similar concerns with justice that we have been discussing. Similar sort of region specific researches can help evaluate the concerns with justice in climate engineering in a more tangible manner. As for the future course of the debate, precise judgements on the justifiability of climate engineering will warrant more technology-specific, context-specific or even nation-specific analysis and assessment. While acknowledging the limitations of this research in this regard, it is proposed to be a proximate agenda for advancing the debate further along the line of justice.

7.5.3 Call for an Eastern and Indian Perspective

It has been noticed in our review of literature that the debate on the ethics of climate engineering, at least in the medium of English, is mostly conducted by the Northern and Western scholars from the developed countries with inadequate representation from the developing countries of the Eastern and Southern part of the globe. Not many ethicists and social scientists from Asia, Africa or South America are seen on the debate scene, though these regions are very vulnerable to the potential risks from climate engineering. This research may be considered as a recommendation to advance the research from the Eastern and Southern perspective as well.

It is hoped that this research will give impetus to more academic and ethical engagement with climate engineering in India. Many Indian scientists are involved in climate engineering research along with European and American scientists. The ministry of earth sciences in India have planned out an $8 million project for carbon sequestration. All the more India is one of the countries most vulnerable to the risks of climate engineering. Despite these factors not

[28] See, Ian Johnson, "European pollution helped cause one of India's worst-ever droughts, researchers show," *Independent, April 21, 2017. Available at* http://www.independent.co.uk/environment/european-pollution-india-drought-worst-ever-sulphur-dioxide-geo-engineering-grantham-institute-a7694491.html. Accessed July 1, 2017.
[29] Ian Johnson 2017.

much has been done in India exploring the social and ethical implications of climate engineering, let alone the concerns with justice. As our review of research has shown, the only peer-reviewed paper on climate engineering from India available on Google scholar dealt not with climate change climate engineering, but with climate engineering in its traditional geological sense.[30] Three of the leading English national dailies in India have published an aggregate of about 25 short write-ups beginning with 2009, some of which are reproductions from *Guardian*[31] and *New York Times*. Thus we hope that this study will fill up some gap in the academic literature by underscoring the need for offering an Indian perspective.

7.5.4 Appropriating Human Rights and Environmental Justice

We have seen that a firm commitment to affirming and respecting the universal human rights against all odds is essential for ensuring justice in climate engineering. While the issues of human rights deserve their legitimate space in a research on justice, our methodic focus on the research question has withheld our attention from engaging the issues of human rights in detail. Engaging the issues of justice in climate engineering with the tragic state of affairs with human rights as shown by Thomas Pogge (2002) emerges as a rewarding and compelling stream of research in the immediate future. Thomas Pogge's startling findings such as 44 percent of human population has only 1.3 percent of global income, 826 million poor people do not have enough to eat, nearly one-third of the deaths are due to causes related to poverty, 80% of the global income is possessed by the 15% of the humankind, etc.,[32] impose themselves upon our research as inviting substantial appropriation from the perspective of climate engineering justice.

Given our exclusive focus on our research question, we have not dwelt systematically upon the issues of environmental justice in climate engineering. While recognizing this limitation, this research recommends the intersection between environmental justice and justice in climate engineering as a priority for future researches.

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[30] See Chapter 3; 3.4.1.3

[31] See for example, Scientists warn of risks from geoengineering, The Guardian Newspapers Limited, April 3, 2013; published in *The Hindu*; http://www.thehindu.com/todays-paper/tp-in-school/scientists-warn-of-risks-from-geoengineering/article4575114.ece. Accessed April 10, 2017.

[32] Thomas Pogge (2002).

7.6 Conclusion

In this concluding chapter we had been retrospective in our approach and content consolidating mainly the responses to the research question. It has also been introspective about the literary and conceptual merits and contributions of this research. Recognizing the limits of the research, we also proposed some research agenda for the future course of research. On the whole we attempted to look at the overall debate landscape from a much-needed philosophical perspective as well.

To conclude this study, we will summarily look at our entire research project. We began this research by framing the research question in order to situate the research in its perspective: can climate engineering be developed in a just manner compatible with the Rawlsian principles of distributive, intergenerational and procedural justice? An approach described as analytically expository and dialogically hermeneutical was also devised. The normative tool for tackling the research question has been precisely the Rawlsian principles of distributive, intergenerational and procedural justice. Hence a significant deal of the work was spared for discussing the Rawlsian scheme in various chapters relative to the aspect of justice under consideration.

A historical and scientific familiarity with the technology under debate was achieved in the second chapter that was followed by a review of the landscape of the ethical debate over climate engineering in the subsequent chapter. On the historical line, it has been observed that though climate engineering is considered popularly as a modern engineering technology, it is the latest stage in a technological continuum. The review of the literature noticed the extreme divide between the proponents and the opponents as well as the areas of consonance between them. Analysing and weighing the diverse argument structures in the review, we picked up one of the urgent and crucial streams in the debate – the issue of justice. Engaging the issue of justice was considered to be of a foundational nature in advancing the debate on the ethical desirability of climate engineering.

Picking up the various normative tools of the Rawlsian theoretical frame on the distributive, intergenerational and procedural justice, we attempted a dialogue between Rawls and climate engineering to see if climate engineering could be developed in a just manner. It has been found that as of now the climate engineering proposals do neither meet the requirements of distributive justice, nor of those of intergenerational or procedural justice. While it has been found that the odds are much against climate engineering and climate engineering presents itself more to be a challenge to justice, we also proposed a number of conditions that will make climate engineering somewhat more compatible with the viewpoints of the Rawlsian distributive, intergenerational and procedural justice. In dealing with procedural justice, we saw that if such radical conditions are met, procedurally climate engineering carries the potential not only to facilitate justice but also to eradicate the prevalent forms of climatic injustice across the globe. Our analysis showed that for ensuring justice in climate engineering, the platform of climatic justice at large has to be ensured first. However, we also noticed that the scope for materialising such an ideal procedure is very dim.

The complexity of the debate is only aggravated by a deeper engagement with the issues of justice and our preparedness for justice in climate engineering calls for unprecedented levels of political goodwill and determination, international collaboration and conservatively alternative ways of life. What we could say with certainty is that under certain conditions climate engineering cannot be regarded as just on the Rawlsian view of justice. This does not necessarily mean that climate engineering cannot be just under any circumstance.

A retrospective introspection of the findings of our research particularly in chapter seven underscored the equally deserving attention to be paid to the wider and fundamental epistemic, conceptual, philosophical and existential issues at stake in the climate engineering debate that are often overlooked due to the pick and choose approach reflected in the treatment of the issues in isolation. The East-West and North-South interface is of vital importance in the prospective development of the ethical discussions along the line of justice. Searching and developing new paradigms of cosmology and anthropology informed by the latest developments in the natural sciences and re-appropriating the ethics of climate engineering in general and of justice in particular under those emerging paradigms is further helpful for a systemically fair statement on the content of justice in climate engineering. Reassuring justice pre-eminently calls for rediscovering our authentic existence as an ecological and social coexistence. It places the ethics of climate engineering in the larger existential *Sitz im Leben* of our ways of living, patterns of consumption, standards of distributions, of our ability to see the diverse nuances of a complex issue systemically, and to resolve them radically and rationally. We also do not fail to observe and appreciate the symbolic but powerful self-criticism of this generation seen on the debate scene that is a tribute to the undying critical rationality of the present humanity. A sustained call for commitment to justice means to recognise that we have not allowed our reason to be completely stolen by simple and short-sighted solutions to complex problems.

Citing Rawls again may well define the contribution of this work to the climate engineering debate altogether: “[W]e are in a better position to assess how serious the existing imperfections are and to decide upon the best way to approximate the ideal.”[33]We may be permitted to quote the popularly “anti-ecological” Bacon, with whom we opened this work, again to conclude this work - but this time, out of context – “[t]he mechanical inventions of recent years do not merely exert a gentle guidance over Nature’s course, they have the power to conquer her and subdue her, to shake her to her foundations.”[34]Even the wildest foresight of Bacon four centuries ago would not have had climate engineering in mind here. But that the reality may be unwittingly getting ready to strike now literally as Bacon metaphorised, we hope our work may be judged as a catalytic homework to scrutinise our climate engineering ambitions to avert any early return of the *yang* – the compounded climatic injustice – and to summon the feeble but gentle voices of the *yin* – the call to restore climatic justice; to use the proverbial Chinese categories again.

[33] Rawls, *Theory of Justice*, p. 272.

[34] Bacon, “Thoughts and Conclusions on the Interpretation of Nature or a Science of Productive Works” (*Cogitata et Visa*) (written 1607), in Farrington, *Philosophy of Francis Bacon* (Liverpool: Liverpool Univ. Press, 1964); p. 93; see also pp. 96, 99.

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