Chapter

The Ethical Desirability of Geoengineering: Challenges to Justice

Augustine Pamplany

Abstract

Geoengineering or climate engineering is defined as a deliberate and intentional intervention into the earth system to combat dangerous climate change. Solar Radiation Management (SRM) and Carbon Dioxide Removal (CDR) are two dominant approaches in geoengineering. From an ethical point of view, both these approaches pose serious challenges to justice from the intergenerational, distributive and procedural point of view. Intergenerational equity and the risk-transfer to future generations suggest major challenges to justice in geoengineering. Abdicating our responsibility is a form of injustice to future generations. Unequal distribution of cost and benefits and benefits and harms is a major challenge to distributive justice in SRM. Paying compensation to those harmed by SRM is presented as a way out of ethical deliberations. But there are serious challenges with regard to compensation for SRM, such as, who ought to pay the compensation, who are the beneficiaries and how much to pay. Participation across vulnerable sections alongside indigenous people and their central involvement remains a concern of procedural justice. Food justice is at stake as the adverse impact of SRM on agriculture and food production is considered to be a major challenge.

Keywords: geoengineerig, climate engineering, justice, equity, intergenerational justice, distributive justice, procedural justice

1. Introduction

It is a general convention that developments in technology beginning with the Industrial revolution has been largely responsible for the unabated exploitation of the earth which in turn has produced the dangerous climate change. Ironically, the awareness of the dangers of climate change has attributed a rectificatory mission to technology, whereby technology itself emerges as a potential option to combat climate change. The technology under reference here is geoengineering, also called climate engineering. This technology is still at its conceptual levels. However, if developed and deployed, geoengineering will carry unprecedented levels of planetary outreach as it is to be deployed in the open and non-encapsulated system of the earth. Serious recourse to geoengineering as a possible response to climate change began with the paper by Paul Crutzen [1] in *Climatic Change*. IPCC's assessment report in October 2014 had references to geoengineering. Solar Radiation Management (SRM) and Carbon Dioxide Removal (CDR) are the two major schemes of technologies under geoengineering. SRM aims at the reduction in the amount of sunlight that reach the earth by deploying

sulphate aerosol particles in the stratosphere, deploying space-based mirrors, cloud albedo enhancement, etc. CDR schemes include biomass, iron fertilisation of ocean, upwelling and down-welling of the ocean, carbon capture and sequestration, etc.

Given the overarching impact and global outreach of geoengineering, both schemes of geoengineering have generated a lot controversy. Since the publication of Crutzen's paper in 2006, there is a hot debate over the ethical desirability of geoengineering. This paper intends to appropriate the ethics of geoengineering from the perspective of justice. A landscape view of the debate setting reveals 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 for and against geoengineering is the primacy of the issue of justice. A review of literature on the ethics of geoengineering in 2020 showed that quantitatively justice has surfaced on the forefront to be the most challenging ethical issue in Geoengineering with the highest number of sources on this subset of the ethics in geoengineering. From a random overview of the literature on the ethics of geoengineering, it becomes clear that the issues of justice are central or foundational to most of the ethical issues associated with geoengineering. Justice enjoys a vantage point from which to partly refute or substantiate and to prioritise some of the leading arguments for and against geoengineering.

As the issue of justice, particularly in the context of climate change, is very complex and wide, for want of clarity and precision, this paper dwells on only three dominant subsets of justice, namely, distributive justice, intergenerational justice and procedural justice. These three aspects of justice are chosen because they are found to be most challenging and intriguing in the context of both schemes of geoengineering, particularly of solar radiation management. The challenges to distributive justice is directly pertaining to SRM as it is a long term deployment across the globe and particularly given its unforeseen effects. Yet another issue of justice challenged by geoengineering is its impact upon the future generations as the deployment of SRM is a long term and perhaps an irrevocable deployment. Thus the issue of intergenerational justice becomes a spontaneous actor to be reckoned on the geoengineering scene. Perhaps, the most overarching concern over justice in geoengineering pertains to procedural justice. As for viable normative judgements on justice over an untested and pioneering technology like geoengineering, procedural concerns are of vital importance. Accordingly, the research question in this paper may be drafted as, *is geoengineering ethically desirable from the standpoint of distributive, intergenerational and procedural justice?*

2. Distributive justice in geoengineering

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. It needs to be evaluated if geoengineering increases benefits for some and harms for others. Proponents of climate justice have called for serious attention to the possible scenario of unjust distribution of cost and harms on the one hand and benefits on the other. The almost unanimous opinion is that there is a serious chance of the prevalent socio-economic inequalities in societies and nations be worsened by the consequences of climate engineering. The asymmetry between harm and benefit and the issues pertaining to compensation are the leading elements of distributive justice in geoengineering.

2.1 Harm-benefit asymmetry

Many a literature on the ethics of geoengineering find that there will be unfair and unjust scenario as regards the distribution of cost and benefits. As such distributive

justice is a major challenge in SRM [2–16]. In the scenario emerging from geoengineering, according to Preston [10], p. 30, "... the interests of the most powerful would be protected, while those less powerful will get secondary consideration (if they are considered at all)." Similarly, Aaron Ray [17] and Schneider [18] believe that the asymmetrical impact of geoengineering is causing serious challenges to distributive justice. Bunzl [19] predicts that 10% of the World's population is set to go worse by geoengineering. Ray [17] observes that there will be no correlation between those who bear the cost of geoengineering and those who would reap the benefit of geoengineering. As for Jamieson [20], p. 329, geoengineering is likely to worsen the plight of the poor people: "People in poor countries. .. have. .. (not) reaped much benefit from the activities that may be resulting in climate change." There is sufficient ground to reasonably share the apprehension of Preston that "The many injustices of climate change foisted on the global poor could be unintentionally compounded by geoengineering" ([10], p. 28).

The critics of SRM from the perspective of justice based their arguments on reliable analysis of scientific models and philosophical frameworks. Some of the philosophical frameworks coined in this context are the egalitarian theories of distributive justice advocated by Ronald Dworkin [21], John Rawls [22], Amartya Sen [23], and Wigley [24]. An analysis of the possible scenario emerging geoengineering using these theoretical models consistently show that there will be huge inequalities with regard to distribution of harms and benefits. Sulphate Aerosol Injection (SAG) will invoke uneven economic and social results [9–11]. Svoboda et al. [11] conclude their study with the observation that despite the significant differences in the various models coined, it is found that "SAG is ethically problematic on all... the major theories of distributive justice...." ([11], p. 178). An assessment of the consequences of SAG imply that it does not meet the requirements of distributive justice, for there will be uneven distribution of harms and benefits upon those who will be impacted by SAG.

The same finding has been confirmed by the analysis of the simulations modelled by Morrow et al. [9]. They find a tragic irony herein that even in the present generation, those who bear the risk of SRM will not receive the merits from SRM. Yet another challenge to distributive justice comes from the involvement of the private parties as major stakeholders in the debate. The profit-driven technological developments will have little appreciation for the just distribution of the harms and benefits. This will skew the benefits of geoengineering away from those who would be most in need of it.

The study by Carr and Preston [25] showed that concerns of distributive justice in geoengineering are intuitively inbuilt among the popular folk. The public opinion on the approval or disapproval of SRM is largely determined by the relative merit or harm to a particular population. The public is also of the opinion that the harms from geoengineering is not comparable with the harmful effects of the climate change, for while the latter is unintentional, the former is a planned programme that calls for aggressive commitment to justice ([25], p. 180).

A significant factor that prevents precise assessments of the challenges to justice is related to the prevalent uncertainty in the geoengineering field. Lack of definitive scientific data poses problems to defining the conditions for distributive justice. The present earth system models are inadequate in giving adequate information on important geophysical factors in geoengineering. The precise estimation of regional impacts and the duration of deployment are still matters of uncertainty in deciding on distributive justice in geoengineering. Hence some authors [14, 17, 20] suggest launching specific research agenda for a comprehensive analysis of the political, social, physical and economic and impacts of SRM. Bunzl [19], puts it all in its real gravity: "[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."

2.2 The issue of compensation

Compensating the harms as a condition for ensuring justice is often proposed in geoengineering discussions [4, 7, 13, 15, 26–34]. Preston [10] underscores the provision for compensation to the most affected in the likely scenario of the poor becoming poorer in the aftermath of geoengineering deployment. Even in that regard, the challenges to justice are not adequately addressed. Study shows that SAG coupled with compensation would not be justified, as such a deal would significantly shoot up the cost of SAG [11].

The proposal of compensating for harm is not that smooth a solution as it appears to be. It invites a series of questions. What is the baseline to decide on the definition of harm and compensation? Howe to adjust compensation to the parties who have caused the harms? What will be the moral responsibility of individual nations to various consequences? How to identify the losers and gainers in the absence of clear baselines and standards? [28]. The very case of Canada and Uganda may be taken as an example of the complexities highlighted here. If there is reduction in global temperature due to SRM, Canada's agricultural yield will decline significantly and conversely Uganda's reduction in agricultural production will be due to the decline in precipitation. It can be seen that both these reductions are of different moral standing calling for different standards for calculating compensation. This motivates Bunzl [28] to propose differentiated moral assessment of the harms caused by SRM. He concludes, "[...] it is unfair for 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" ([28], p. 73).

Similarly, there are also dormant paradoxes in the seemingly sound ethical assumption of compensation [35]. That there is a possibility for compensating harm cannot be considered as a licence or justification to inflict harm. The general ethical practice of penalising the parties who caused the harm to pay the compensation will make any sense if only the benefits of geoengineering is greater than the costs it incurs. As of now, there is no conclusive evidence to suggest that the benefits will outweigh the harm. Accordingly, the issue of compensation carries an inherent contradiction. Thus there is no justification for 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" ([35], p. 7).

Marion Hourdequin [36] thinks that there is every chance of climate injustice being exacerbated if the governance, research and deployment are confined to a very few powerful hands. Monopoly of research and deployment is least compatible with justice. She thinks that only the ideals of solidarity and relationship at the societal and technological levels can ensure justice in this context. Hourdequin [37], shares an optimism that a collective response can ensure distributive justice in the context of technological intervention. Hourdequin [36, 38, 39] has highlighted several major nuances of the issues of justice in geoengineering. McLaren is of the opinion that present risk managerial approach to justice is insufficient in the geoengineering context and we need a "relational, care-based imaginary of the future" ([40], p. 2).

2.3 Distributive justice and food justice

Recently, concerns have also been raised over the dangerous impact of SRM on cultivation, and food production. The consequences of SRM for food justice is to be significantly correlated with the issues of distributive justice in geoengineering [41].

Due to complex relationality between geoengineering and food production, it is normatively obligatory to ensure sufficient and sustainable production of nutritional food before advancing with geoengineering [42].

2.4 Care and virtue ethics perspectives

Concerns about distributive justice in SRM are raised also from the viewpoints of virtue ethics and care ethics. From the perspectives of virtue and care ethics, the assessment is that the principle of fairness will not be respected in the SRM scenario [43, 44].

It appears that from the justice point of view, even researching geoengineering could be like opening a Pandora's Box. It is unequivocally agreed by the parties in the debate that greater research is essential for addressing the issue of distributive justice. With the present range of research that are confined mostly to computer simulation, there can be no definitive judgement on the challenges to distributive justice in geoengineering. Unsurprisingly, the dominant approach in the literature on justice in geoengineering is to see geoengineering as a serious challenge to distributive justice from whichever form of geoengineering, mostly stratospheric aerosol injection. This is not to overlook the nominal voices that argue that geoengineering would present itself as providing positive opportunities for global distributive justice and equity [45, 46].

It could be noted that there are no adequate context-specific studies on the impact of geoengineering on justice. Unfortunately, the debate on distributive justice is extremely polarised towards the analysis of SRM technologies with less attention paid to the distribution of the harms or benefits of CDR approaches. Though the issue of climate justice in relation to anthropogenic climate change is extensively researched (E.g., [47]), most of those researches fall short of addressing the challenges to justice from geoengineering.

3. Intergenerational justice in geoengineering

Geological history shows that there is a global impact for any local climatic intervention. The temporal impact of such interventions cannot also be confined to a particular period. This fact is of particular importance in geoengineering as it is self-evident that the impact of the climatic interventions by this generation will not be confined to this generation. The future generations are naturally brought into the debate on the ethics of geoengineering. This is how intergenerational justice is of decisive value in the geoengineering debate. While distributive justice is challenged by the spatial factors resulting from geoengineering, intergenerational justice is challenged by the temporal imbalances.

The proprieties of distributing harms and benefits between the present and future generations is the focus of intergenerational justice. It assumes that natural resources are not to be entitled unlimitedly to any particular generation. As custodians of natural resources, each generation has to fulfil its obligations to the future generations. It involves the safe custody and preservation of the natural resources for the sustenance of the future generations. This is the reason why intergenerational justice forms a major component in any theory of ethics. It is a happy state of affairs that due importance is given to this principle in international treaties and conventions. There can be no fair treatment of justice in geoengineering without adequately appropriating the challenges to intergenerational justice.

As we discuss below, the contested issues of intergenerational justice in geoengineering revolve around the concerns over the problem of sudden termination of

SAG, questions concerning the agencies of pollution, the challenge of moral hazard caused by the technical interventions, the danger of treating the symptom over the cause, and the present generation transferring the risk to future generations.

3.1 Responsibility of the current generation

The paradoxical issue in intergenerational justice in geoengineering is that future generations are forced to bear the brunt the harms caused by the unnatural ways followed by the current generation. The policies and practices of the present generation concerning development and the consumption of natural resources are largely instrumental in creating a situation of having to geoengineer. However, the effects of geoengineering by this generation will be transferred to the future generations [27, 28, 35, 48–56]. This implies that this generation will reap the benefits by transferring the risks and harms to the future generations. This is often termed as the risk-transfer argument [54] or responsibility abdication objection [57]. A fair practice in this regard would be the polluter-pays principle. This principle, formulated by Betz and Casean [27] assumes that those who caused the dangerous climate changes should also pay for it. Abdicating our responsibility for the dangerous climate change imply that the present generation lets itself off from its offences.

3.2 Moral hazard

One of the major arguments against geoengineering is the challenge of moral hazard – the fear that geoengineering may water down the efforts at mitigation. Royal society coins the phrase "get out of jail free" ([58], p. 276) to mean the same. The ramifications of moral hazard are extensively discussed in the geoengineering debate. Moral hazard is often coined in the insurance context meaning that the security offered by the insurance coverage may trigger the confidence of the insured to venture into riskier activities. Similarly, the true or false hope in the technical solution by geoengineering may alleviate the efforts at mitigation. The assumption that there is a solution to an imminent problem will defer the aggressive measures that may otherwise be warranted in such a scenario. The luxurious life-style of the present generation is largely responsible for the ecological havocs and conservative solutions like change of life-style is called for to fix it. Now, as championed by certain proponents, if geoengineering is economically so feasible, the psychological impetus for a conservative solution naturally withers away. Such a lose commitment to mitigation by this generation means a heavy penalty upon the future generation for something which they are least responsible for.

The possible postulation of a hope of solution leads to avoiding the moral obligations towards climate change by the present generation. As for Gardiner [51] geoengineering is an evasive loophole found by the present generation to skip its moral obligations. As for the present generation, the problem of climate change is less apparent and imposing owing to factors like geographical dispersion of the various and diverse agents and effects of climate change and the pertinent scientific uncertainties about it. These are justificatory weapons of the present generation against its moral obligations. Gardiner [51], p. 408, thinks that climate change is such a 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." The vices of the present generation include moral corruption – subversion of the moral discourse to one's own favour – and passing the buck to the future generations. Researching and pursuing geoengineering is an acknowledgement that the present generation has "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" ([51], p. 408).

3.3 The termination problem

Termination problem is the possible danger of global temperature bouncing back rapidly if SAG is suddenly terminated. Scientific estimations suggest that if SAG is terminated, there is the possibility of global temperature shooting up faster than the pre-geoengineering phase. This scenario imposes serious restrictions on the choices of the future generation to combat climate change. Most ethicists consider the problem of sudden termination to be the most challenging issue from the point of view of intergenerational justice.

If SRM is discontinued for unforeseen reasons, the worst case scenario is that it could result in the extinction of several species including humans. Svoboda et al. [11] used the theoretical model of Dworkin [21], Rawls [22], Sen [23], and Wigley [24], to assess the issue of intergenerational justice in the likely scenario of sudden termination. They found that in all these models there is a serious violation of intergenerational justice. According to Svoboda et al., "… intergenerational justice requires the present generation to ensure that future generations have access to food, water, shelter, and education.… any generation that implements SAG …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" (2011, p. 173).

Apart from sudden termination, the long-term deployment of SRM also add to miseries of the future generations. There are scientific estimations predicting that a continuous deployment of around 500 to 1000 years may be required to contain the global warming. It means that the values and priorities of the future generations will be significantly conditioned by the existential challenge of SRM [11].

There are serious methodological limitations in estimating the issues of intergenerational justice in geoengineering. For instance, in the given scientific scenario, it is not clear how many future generations will be impacted by geoengineering and it is impossible to determine whether a future climatic impact is due to geoengineering or due to natural reasons. The identity and population of the future generations are also unknown. Accordingly, scientific uncertainties with regard to geoengineering poses serious hazards in assessing the full scale and length of the concerns with intergenerational justice in geoengineering.

3.4 The governance challenge in intergenerational justice

At this juncture it could also be asked if there are any positive factors in SRM towards facilitating intergenerational justice. After all there are voices claiming that SRM would promote equity as it is capable of avoiding the tragedy of the commons by doing away with the various forms of injustice caused by anthropogenic climate changes. It is also argued that the present generation empowers the future generation to contain the dangers of climate change by SRM [45, 46]. There are arguments that SRM would shield the future generations from otherwise future catastrophe. This is termed as the buying-time argument implying that SRM allows sufficient time for this generation and future generations to combat climate change. Thus proper governance mechanism would ensure intergenerational justice.

This observation, thought seemingly positive, is loaded with major practical challenges. The study by Burns [48] and Svoboda et al. [11] show that even in such scenarios SRM will be incompatible with intergenerational justice. Given the nature of the present international treaties on climate and environment, no law or

convention is capable of absorbing the possible complexities posed by SRM ensuring a consensus on the deployment of SRM in a manner compatible with intergenerational justice. Treaties such as UNFCCC (United Nations Framework Convention on Climate Change), ENMOD (United Nations Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques), and CBD (United Nations Convention on Biological Diversity) are not framed for geoengineering and as such they enjoy no comprehensive governance over it. Burns [48] opines that even if UNFCCC may claim certain authority, the lack of political determination will not ensure the just deployment of SRM. Since the very need for SRM is caused by the lack of political will, it cannot be assumed that the same would be present in ensuring justice in its deployment. Although ENMOD permits interventions with environment for peaceful purposes, the limited number of signatories to it does not give a credible mandate for ENMOD over SRM. Similarly, though CBD may be invoked in SRM or CDR, the terms of the CBD have no binding force on the parties as they are only recommendations to parties. The absence of proper governance mechanism seems to confirm that there is no way of deploying geoengineering in a manner compatible with intergenerational justice though some authors tend to think so.

As the critique so far had been around the challenges of SRM to intergenerational justice, one might be inclined to consider CDR to be compatible with intergenerational justice. It is clear that CDR does not invoke concrete problems like sudden termination. At the same time CDR is not freed from the possible moral hazard that it may cause. The moral hazard issue of alleviating the aggressive commitment to mitigation is equally present in CDR projects too. Besides, the required sustained deployment of CDR techniques "would deny them (future generations) the full panoply of options that the principle of intergenerational equity demands" ([48], p. 218). It may be granted positively that on a comparative scale, CDR schemes are not as challenging as the SRM schemes in regard to intergenerational justice. It should be noted alongside, that despite the reduced challenges to justice from CDR, the almost exclusive focus in the debate is on the SRM techniques with very little research being done along the CDR line. A full-blown commitment to the issues of intergenerational justice would require that this strategy needs serious rectification. Burns' [48] formulation that SRM "sows the seeds of a major peril for future generations" ([48], p. 209) may sum up the gist of the discussion on intergenerational justice in the context of geoengineering.

4. Procedural justice in geoengineering

Perhaps what is most rewarding at this stage of the debate on justice in geoengineering is the discussion on procedural justice. It is to the merit of the ethicists that the challenges of procedural justice have been brought to the forefront at the deliberative level itself. As it stands, the discussion on the choice of technologies can be significantly influenced by the concerns with justice.

An untested technology in search of its ethical normativity, but confronted with looming uncertainties about side-effects, will warrant a clear articulation on the procedures towards policy decisions on the choice of technologies, governance mechanism, field tests, etc. Accordingly, the leading issues pertaining to procedural justice coined today are participation and consent, moratorium on field tests, evaluation of the results of technology, security threats stemming from the deployment of technology, etc.

4.1 Consent and participation

The principle of informed consent emphasized by ethicists for the safety of the research subjects is a universal norm in research ethics. It ensures that the subject who voluntarily partake in a research is adequately informed about the risks involved in such a participation and the subject's consent is obtained only after imparting sufficient information. The issue of consent presents itself as the leading contender challenging procedural justice in geoengineering [4, 5, 10, 50, 56, 59]. Preston [10] has rightly identified informed consent to be a formidable challenge in geoengineering at the level of research and deployment. "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 geoengineering 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" ([10], p. 29).

While informed consent is essentially significant for geoengineering researches, obtaining such a consent is extremely problematic given the complexities involved in geoengineering. The conventional models of informed consent are no longer useful in the geoengineering context. The principle of informed consent meets challenges such as identifying the victims of the research and deployment, the huge number of population who will be affected by the technology, the difficulties of representative consent, etc. The conventional practice of obtaining representative consent look impractical in a technology with global impact.

The solution proposed by Morrow et al. [9], upholding the principle of respect as a motivation towards ensuring consent for geoengineering, does uphold the values of procedural justice. Morrow et al. [9] suggest that "[…] the scientific community secure the global public's consent, voiced through their governmental representatives, before beginning any empirical research [on geoengineering]" ([9], p. 1). This norm does prevent the public from having to accept a policy to which they have given no consent.

4.2 Unilateral deployment and issue of consensus

Another problematic that is anticipated in regard to procedural justice is the issue of a single nation most hit by the dangers of climate change unilaterally deciding to deploy geoengineering in a desperate situation. Even in this regard, procedural challenges cannot be ignored as the impact of the deployed technology is not limited to the nation under consideration. Informed consent cannot be assumed even in a such a desperate scenario [60].

The scope for the unilateral deployment is a central challenge to procedural justice in SAG [27, 45, 61–65]. The leading approach among ethicists is to caution against unilateral deployment.

Assessing procedural justice in geoengineering against the theoretical frame of Rawls does not give nod to research and development. From the Rawlsian point of view of procedural justice, in the present state of affairs with geoengineering, there is no deliberation let alone agreement among all stakeholders and those who would be affected by it. Such a consensus is central to the Rawlsian procedural justice. As such the projected fear about unilateral deployment of SAG should not occur in the Rawlsian context. Analysis by Svoboda et al. [11] showed that these conditions cannot be met in unilateral deployment, particularly as there is no governance mechanism for appeal against SAG.

Denouncing unilateral deployment does not imply that SAG itself is procedurally unjust. Svoboda et al. [11] has opened another unique stream of thought along procedural justice arguing that the unilateral SAG does not make geoengineering in itself procedurally unjust.

4.3 Non-ideal theory of justice

The proponents have recently introduced the notion of non-ideal theory of justice into the geoengineering debate. As the world and its structures are never ideal as it ought to be, it is important to have a realistic approach to geoengineering. It requires considering what matters for justice in circumstances where there is only partial compliance. Accordingly, a non-ideal approach should be taken towards SRM for SRM is a typical instance of the on-ideal theory of justice [4, 13, 66].

Procedural issues in geoengineering should be driven by non-ideal considerations as well. Conversely, recourse to clinical theory, a subset of non-ideal theory, which holds that "politically feasible institutions or policies that would address existing… injustice without violating certain kinds of moral permissibility constraints" ([66], p. 85) is also made in the discussions on procedural justice in the current context.

4.4 Public engagement

Yet another recommendation made towards developing geoengineering researches procedurally just is to treat geoengineering as a public good. The Oxford geoengineering group has proposed the idea of considering geoengineering as a global public good [67, 68]. Treating geoengineering as a public good would imply public participation in decision making process, ensuring transparency and disclosure of research methods, independent assessment of the impacts and developing proper governance mechanisms before deployment. A modified version of the Oxford principles was also endorsed by the Asilomar geoengineering conference in March 2010. Preston [10] observes that "Oxford principles are notable for stipulating that geoengineering should not be driven by profit-raising questions…" ([10], p. 28). Despite the popularity of the Oxford principles among geoengineering ethicists, it has not gone without critical scrutiny. Gardiner has expressed strong reservations against treating geoengineering as a public good as that alone would not suffice for geoengineering to be procedurally just [60]. According to Gardiner, Oxford principles fail to meet the conditions of non-excludability and fairness. Alternately, he proposed the tollgate principle with greater emphasis on fairness, legitimacy and respect [5].

Despite its vital importance, empirical studies showed that justice concerns still remain an under-recognised factor in the response of the public towards geoengineering [69, 70]. Some models of public engagement include upstream public engagement [71], and supermajority rule [72]. The importance of involving the public in decision making process was emphasised by the Royal Society [58] too.

4.5 Principles of beneficence and minimization

Principles of beneficence and minimization [9] are also coined as normative principles in the geoengineering debate to make research and development of geoengineering procedurally just. Principle of beneficence coupled with justice warrants that there should be a "favourable risk–benefit ratio and a fair distribution of risks and anticipated benefits […]." As the long time span of geoengineering does not permit achieving a favourable risk–benefit ratio, they also advocate the

minimisation principle. As the term itself suggests, this principle suggests keeping the extent and intensity of the research and field tests to the minimum. The purpose of minimum intervention is to avoid as much risks as possible. In the absence of "risk-knowledge calculus" [9] informed by scientific input on the risks and benefits, a maximin approach can be normatively helpful. As per the maximin approach population that are most vulnerable to risks and least likely to benefit deserves special attention.

As already discussed in this paper, ethical deliberations in geoengineering are operating against a lot looming uncertainties. Accordingly, the precautionary principle, a tool towards making decisions under uncertainties, finds it natural inroads into the geoengineering debate [73]. Although precautionary principle could provide some useful tips to make it procedurally just, the debate scenario does not provide a consensual opinion on the interpretations of the precautionary principle in the geoengineering debate. Some strong variants of the precautionary principle call for a total ban or moratorium on researches on geoengineering. The weak version emphasises the focuses on avoiding harm in matters of choices under uncertainty and hence an uncompromising approach to harm would be the norm for geoengineering researches too.

The possibility of the research and development being skewed towards military intentions is a major issue that demands proper procedural protocols [74]. The chequered history climate modifications is loaded with such misuse of technology as in the case of Vietnam War. The prevalent terrorist challenges pose maximum procedural caution against the technology being hijacked by ill-intentioned groups [71]. Guarding against such possible aberrations is a necessary condition for advancing procedural justice in geoengineering.

5. Conclusion

This paper tried to analyse the ethical desirability of geoengineering from the point of view justice. The analysis suggests that geoengineering, particularly SAG, conceived in its present format carries serious and almost irreparable damages to justice in its three major variants of distributive, intergenerational and procedural justice. Although the present analysis may seem to go heavily against geoengineering, it could be noted that the ethical desirability of geoengineering is not exclusively confined to the issues of justice. As such the motive here is not to reject geoengineering altogether, rather to motivate the proponents of geoengineering to meet the conditions of justice before researching, developing and deploying geoengineering.

Author details

Augustine Pamplany[1,2]

1 Institute of Science and Religion, Little Flower Seminary, Aluva, India

2 Little Flower Institute of Philosophy and Religion, Aluva, India

*Address all correspondence to: apamplany@gmail.com

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