Ethics of Climate Engineering: Don't forget technology has an ethical aspect too

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Abstract

Climate change may well be the most important issue of the 21st century and the world's response, in the form of 'Climate Engineering', is therefore of equal pre-eminent importance. However, while there are technological challenges, there are equally just as important ethical challenges that these technologies also generate. Governments, funding agencies and non-governmental organisations increasingly recognise the importance of incorporating ethics into the development of emerging technologies (for example, within the EU draft legislation on AI). As the world faces the global challenge of climate change there are urgent efforts to develop strategies so that responses to the climate problems do not reproduce more of the same. Ethical values from the onset are fundamental to this process and need highlighting. Hence, this paper analyses a series of ethical codes, framework and guidelines of the new emerging technologies of climate engineering (CE) through a review of both published academic literature and grey literature from either industry, government, and non-governmental (NGO) organisations. This paper was developed as part of a collaboration with international partners from TechEthos (TechEthos receives funding from the EU H2020 research and innovation programme under Grant Agreement No 101006249; Ethics of Emerging Technologies), an EU-funded project that deals with the ethics of the new and emerging technologies anticipated to have high socio-economic impact. Our findings have identified the following ethical considerations including autonomy, freedom, integrity, human rights and privacy in the developmental process of climate engineering, while a poverty of ethical values reflecting dignity and trust were noted.

Keywords: climate engineering, ethics, autonomy, freedom, human rights, integrity, privacy, codes, guidelines, frameworks

1 Introduction

As many of the world's leaders meet in Glasgow in 2021 for COP26[1], a climate emergency is declared by campaigners, activists and academics. There is a consensus in academic and policy making narratives of climate change that points to a rise in global temperature, greater rise in sea levels, and consequentially ushers in detrimental and catastrophic harms to biodiversity and threatens millions of lives.

COP26 is "an event many believe to be the world's best last chance to get runaway climate change under control" say the organisers of the conference (https://ukcop26.org/the-conference/how-is-cop26/). The event, jointly hosted by the Italian and UK governments, has reignited the world's attention on climate issues. An avenue for addressing climate issues comes from technologists, who are at the forefront of developing innovations and as such require our urgent ethical attention. While on the one hand there has been considerable attention paid to the negative consequences of climate change, very little has consistently been paid to the engineering technologies to address these issues, or the ethical effects of these technologies – will they be able to solve a climate problem with technology, or contribute to further environmental harms? Will social inequality

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be addressed in the process, or exacerbated? Notably, in 2017 the global organisation UNESCO addressed this issue by adopting a "Declaration of Ethical Principles in relation to Climate Change" (UNESCO, 2017).

Working as part of the TechEthos consortium, a project funded by the European Commission, our research aims to map the ethical issues, sometimes of technologies that are in nascent stages and as such their full effects are not yet known. One of the criticisms of climate technologies is they are part of the 'Bright Green Lies' (Jensen, Keith and Wilbert 2021) and thus the technologies and practices that created the problem (including the resources required to produce them) are now sought out as the solution. While we are unable to solve the complex array of issues involved, we have looked at what the various stakeholders involved – industry, governments, non-governmental (NGO) organisations - have said or done regarding the ethical aspects by collecting codes, frameworks and guidelines and identifying the ethical issues flagged in these documents. This research is not conducted in a vacuum with many international organisations emphasising a parallel process of ethics+technological development, so they are produced together rather than as technology followed by an ethical response.

This paper presents some of the findings from this ethical scan of climate technologies, in order to identify the key ethical issues for such an important set of technologies, and hopes to inform further developments.

2 Literature search strategy

The methodology for this literature scan was constructed using a mixed method approach. As a first step, we identified published reports, academic journal articles, books, and working papers that examined guidelines, ethical codes of conduct, and governance frameworks, as used within climate engineering.

The key terms we used are:

- 'ethical codes'
- 'ethical frameworks'
- 'ethical guidelines'

Once the ethical frames (codes, frameworks and guidelines) were retrieved, we further scanned the results further based on a selection of several fundamental ethical principles extracted from Brey (2012) who proposed this extensive ethics checklist (see Table 1), which encompasses a range of ethical values and principles, based on ones that have been seen in earlier ethical approaches and commonly found within society.

Table 1 Selected Ethical Principles and Concerns, based on Brey (2012)

Fundamental principles
Impact on: • Human rights • Freedom • Autonomy • Integrity • Responsibility • Privacy • Security

The databases we searched included JStore, Google scholar, ACM Digital Library, IEEE Xplore Digital Library, AIS eLibrary, and we also carried out a general search on Google where we often found reports from organisations that are traditionally excluded from academic databases. There is a growing trend in science, of carrying out systematic literature searches including the results from Google Scholar, as for example shown in Seid et al (2018). To this end, we considered carrying out a comprehensive literature review search to assess whether this method would provide us *both* with a sufficient quantity *and* variety of relevant sources. Our aim was to obtain a set of documents, comprising of both published academic literature and grey literature from either industry, government, and non-governmental (NGO) research and policy organisations that would have ethical guidelines, codes and frameworks as a key content in their text. We did not seek to include texts which mentioned ethical principles in general without reference to specific guidelines, codes and texts.

The search algorithm used in the search was:

("Abstract":ethic*) AND ("Abstract":guideline) AND ("All Metadata":Climate Engineering)

That is:

1. 'ethic*' - which encapsulates ethics and all terms with ethics included – *within* ABSTRACT (this key term had to be present in the abstract of the document);
2. 'Guideline OR Framework OR Code' - *within* ABSTRACT and/OR author KEYWORDS;
3. Technology family or specific technology type e.g. 'Climate engineering OR carbon capture – *within* All Metadata

The keyword 'ethic*' would capture documents containing all key terms related to ethics, such as 'ethics', 'ethical', 'ethic' at once, without needing to perform separate searches for each of the terms.

The results of the search were saved and imported into Zotero, a reference management software to manage bibliographic data that can be shared across different research teams. We saved more than the 20 sources for scrutiny of relevance, that is, to assess whether ethical guidelines, codes and framework were being foregrounded in the documents.

3 Definitions of ethics guidelines/frameworks/codes

We sought to identify relevant ethics guidelines/frameworks/codes within the selected sources which we refer to as 'literature scanning' in this report. We note that the terms guidelines/frameworks/codes were used interchangeably in the literature. We also understand that guidelines/frameworks/codes can indeed be interrelated to each other in a complex manner, sometime hierarchically (for example codes and guidelines are considered by some as subcomponents of frameworks), hence are not strictly reducible to paradigmatic, self-contained definitions. However, for the purpose of this scanning exercise we did not aim to delineate such interrelations nor the hierarchical levels to which guidelines/frameworks/codes pertain since this would constitute a deeper level of analysis. For the scan, we utilised a technique aimed at *detecting* these ethical frames as they occur in the literature, not as they interrelate. With this in mind, we identified the main difference between these terms to lie in their level of generality i.e. ethical codes have a narrower and more specific focus and guidelines have a broader scope, with frameworks laying somewhere in the middle in terms of level of generality. Below, we captured and articulated further the distinction amongst these terms based on the example set by Rothenberg et al. (2019) and we generated definitions of these terms with the purpose of defining in a clear-cut manner what constitute ethical codes, guidelines and frameworks.

3.1 Ethical codes

Ethical codes set forth responsibilities to which individuals and groups or organisations hold themselves to account. Compliance with codes may be enforced with socially mediated consequences for non-compliance or rewards for compliance. Related to emerging technologies, ethical codes elevate individual responsibility to promote desirable and/or minimize undesirable developments in the field.

- Target: individuals, groups, organisations
- Proximal Goal2: enhanced responsible behaviour in the field
- Distal Goal: enhanced desirable and reduced undesirable outcomes of activities in the field
- Compliance: determined by social pressures; in rare cases also formal sanction
- Scope: may be unique to individuals/organizations or shared across many entities

3.2 Ethical frameworks

Ethical frameworks set forth general or specific principles to which countries, organizations, or research communities hold themselves to account. Frameworks arise in otherwise unregulated situations where groups of

[2] Proximal refers to objectives to reach in the short term which have higher probability but lower value. Distal refers to objectives to be achieved in the longer term which have lower probability but higher value. People are more likely to persist and achieve distal goals if they are linked with proximal goals.

actors seek to alter the development trajectory of a field. Compliance with frameworks may be enforced with socially mediated consequences for non-compliance or rewards for compliance. Related to emerging technologies, ethical frameworks seek to coordinate alignments of the behaviour of collectives of individuals to promote desirable and/or minimize undesirable developments in the field.

- Target: countries; organizations; research and innovation communities
- Proximal Goal: enhanced coordination of responsible behaviour by disparate groups of actors in the field
- Distal Goal: enhanced desirable and reduced undesirable outcomes of activities in the field
- Compliance: determined by social pressures; in rare cases also formal sanction
- Scope: shared across many entities

3.3 Ethical Guidelines

Ethical guidelines collect general or specific principles specifying how a technology or field ought to develop. Guidelines may be generated through concerted collective action of individuals or organizations. Compliance is not usually considered with guidelines. Related to emerging technologies, ethical guidelines propose development pathways intended to enhance desirable and/or minimize undesirable outcomes of a field.

- Target: research and innovation pathway of a technology or research area
- Proximal Goal: agreement on responsible directions for a technology or research area
- Distal Goal: enhanced desirable and reduced undesirable outcomes of a field
- Compliance: not usually considered
- Scope: shared across many entities

4 Mapping

The strategy that this ethical documents' review follows was set by Rothenberg et al (2019: 4); their review of ethical guidelines of AI extracted common guidelines from a select sample of relevant literature, grouping them based on the ethical principle that underwrite them. They included the type of organization issuing the guideline and a definition for each.

Table 2 Example showing classification of ethical guidelines, codes and frameworks

Ethical guidelines, codes, frameworks and issues (based on Rothenberg et al 2019)			
Guideline	**Type of organisation**	**Definition**	**Extract of source guideline**
Ethical code	Academia	Ethical codes set forth responsibilities to which individuals and groups or organisations hold themselves to account.	"Private actors with an interest in carrying out geoengineering research may not be aware of, and subject to, the same professional and ethical standards of professional scientists" (Hubert, 2021).
Ethical frameworks	Academia	Ethical frameworks set forth general or specific principles to which countries, organizations, or research communities hold themselves to account.	"Part of the challenge of producing a clear and credible governance framework is determining the scope of application; that is, defining what kinds of experiments are even subject to review as a geoengineering experiment" (Winickoff and Brown, 2013).
Ethical guidelines	Academia	Ethical guidelines collect general or specific principles specifying how a technology or field ought to develop	"How binding must regulation be? Are mere 'guidelines' acceptable?...More recently, the UK's Royal Society, in partnership with a major US environmental organisation and the developing world's network of academies of science, launched the SRM Governance Initiative, which 'seeks to develop guidelines to ensure that geoengineering research is conducted in a manner that is transparent, responsible and environmentally sound" (Reynolds, 2011).

5 Climate Engineering

5.1 Ethical codes

With regards to *ethical codes* within climate engineering (CE), the search produced references from academia, including one working paper. According to Lawlor and Morely (2017), given the current exacerbating climate emergency, any existent (if any) codes or ethical principles have proven insufficient. Extrapolating this point further, Hubert (2021) states that private entities that have an interest in engaging in CE research may be both unaware of and extricated from following the ethical standards of other professional scientists. For example, Jinnah et al. (2019) argue that the scientific community that is conducting certain forms of CE (i.e., Solar Radiation Management - SRM) should delimit what constitutes responsible SRM and, that funders of such research should oblige researchers to comply with such a code. As a potential solution, in 2015, Hubert and Reichwein argued that the inter-governmental Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries could serve as a potential exemplar for developing a code of conduct for CE research. Boettcher (2019) warns however that an overly broad code that may miss the mark contrasted with one that is flexible enough to be adaptable with changing technological and social needs. Again, as a potential response, Morrow (2017) says that soft-law approaches to governing CE in the form of codes of conduct would constitute such an example of a flexible and adaptive regulatory tool.

5.2 Ethical frameworks

When it comes to *ethical frameworks*, we found references from academia, including working papers. Morrow et al. (2009) called for the international community, including ethicists, to engage in dialogue regarding the social benefits and risks of CE research given the lack of a generally accepted frameworks. Winickoff and Brown (2013) reiterate the issues regarding a clear and delimited governance framework for CE experiments and the need to clearly define them. As a potential solution, Bellamy (2015) proposes a sociotechnical framework for CE governance that acknowledges the ethical issues of the systemic effects of the technologies of emerging sciences like CE. As example of similar efforts, Svodoba (2017) mentions the United Nations Framework Convention on Climate Change (UNFCCC), Reynolds and Horton (2020) the Earth System Governance (ESG) Research Framework, and Hartzell-Nichols (2012) proposes the Precautionary Decision-Making Framework (PDMF).

5.3 Ethical Guidelines

Concerning *ethical guidelines*, we also found references from academia, including working papers. Morrow et al. (2009) propose that ethical guidelines for CE can be derived from the literature on ethics, specifically research involving both human and animal subjects, as these can be applied directly to CE research. This reflects CE research being relatively new and lacking clear guidelines *per se*. Hubert and Reichwein (2015) reiterate this by saying that although the scientific community has general guidelines regarding research, such large-scale research in the open environment does not have any set guidelines. Further, Reynolds (2011) questions how binding such guidelines would be, stating that there are already global initiatives to develop such guidelines for CE research. Morrow (2017) argues that guidelines for CE should be clear and qualitative and that as the scope of the impacts of CE research increases, so too will the proportion of the strictness of those guidelines.

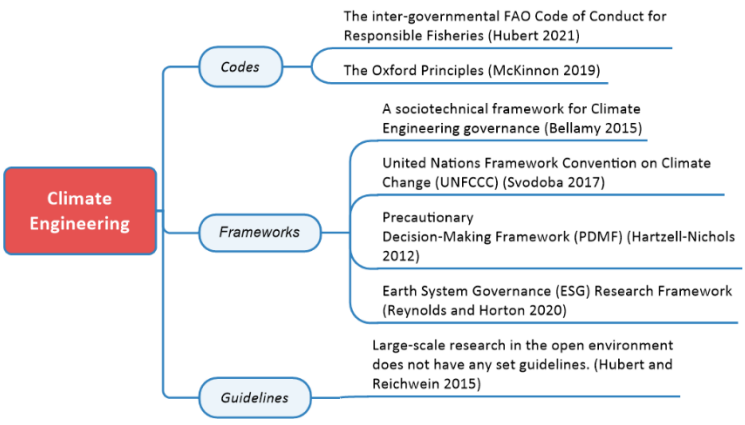

Figure 1: Mindmap of existing and published ethical codes, frameworks and guidelines for climate engineering identified in the scan. (The references in bracket refer to either the original author of the frame, or to the scholar citing the frame. Proposals for new ethical codes, frameworks and guidelines for climate engineering are not included in this map.)

5.4 Ethical principles

The results of this ethical scanning were then further interrogated, based on analytical terms suggested by Brey (2012), see Table 1. That is, we searched for the key ethical principles of autonomy, integrity, freedom, human rights, privacy in the documents.

5.4.1 Autonomy

Discussions of *autonomy* are centred around citizens' rights/ability/choice to participate in CE. This may come in the form of scientists' freedom to research CE (Hubert, 2021) to citizens' ability to participate in CE research as potential subjects of its impacts. For example, both Morrow et al. (2019) and Reynolds (2011) discuss how the global impacts of CE can feasibly impact on all humans, thus raising questions of human autonomy at the global scale.

5.4.2 Freedom

While we understand that climate engineering raises some interesting issues related to *human freedom* such as the ability to live independently, the only references we found in the selected sources concerned freedom of research. We found this to be still a relevant context as it points to the dearth of research on CE and its resulting lack of information on the efficacy, risks, and benefits of geoengineering measures which will support better informed decision-making in the future. Ensuring scientific freedom in research could be an ethical measure to remedy this issue. In this regard, Hubert and Reichwein (2015) point out that freedom of research is often mentioned within guidelines for CE research, the concept is less focused on in international law. Hubert (2021) continues by saying that although scientific freedom is often a starting point, and a central topic in CE governance approaches, it nonetheless is upheld more by the self-organizing bodies of researchers rather than international governance structures.

5.4.3 Human Rights

Human rights were discussed by Morrow et al. (2009) who explain how the far-reaching impacts of CE experiments require the identification of the relevant human rights that may be affected by such experiments. Hubert and Reichwein (2015) argue that the right of scientific research is often a predecessor to other human rights. As such, in the UN Declaration on Human Rights there is the right to 'share in scientific advancements and its benefits' (Reynolds, 2011). Because of this, the impacts and benefits of CE on human rights require multi-stakeholder engagement (Jinnah, 2018) and the responsibility and right for everyone to enjoy the benefits of CE research and application (Hubert, 2021).

5.4.4 Integrity

Integrity as an ethical issue was mentioned by Hubert and Reichwein (2015) who argue that there are limits to scientific freedom. There are certain obligations that scientists have in order to ethically benefit from such a freedom, this includes integrity (among other principles) in their practice of science. This notion has been better unpacked by Mitcham (2003) and linked to responsible innovation by Stilgoe et al (2013). Mitcham (2003) conceives integrity not just in science but in the science-society relationship and explains it in terms of "co-responsibility". This is made of two principles, 1) that of role responsibility, which has then undergone significant evolution from "collective responsibility" to 2) the notion of responsibility resting with a "trans-scientific community." (2003: 273). Stilgoe et al reminds of the role of research integrity within the process of ethical governance of CE, especially when humans and animals are involved, as they would inevitably be in CE (Stilgoe et al 2013: 1569).

5.4.5 Privacy

Privacy had only one mention. Reynolds (2011) mentions the concerns with privacy breaches when communicating research results and the particular issues with CE research dissemination. Given the potential militarisation of CE research, the concerns of keeping potentially dual-use CE research private is of particular interest. This is problematic when the experiments undertaken are not an issue, but the potential interpretation (regarding application) of the results are, and this may trigger unnecessary regulation.

6 Conclusion and grounds for further work

In scanning the literature related to climate engineering we unpacked several key ethical issues, some of which were specific to this emerging technology, and others which also apply more broadly. Ethical paradigms are cultivated primarily in the Western juridical-legal-ethical context, and because of this, issues to do with personal

autonomy, freedom, integrity, human rights and privacy were highlighted in the analysis of the texts. When searching for these ethical principles within the selected documents, we often came across other themes mentioned within the same paragraph or group of paragraphs, which were covered in our list. Although we did not specifically pre-select the themes of dignity and trust, it was surprising that such themes were less obvious in association with discussions of autonomy, freedom, integrity, human rights and privacy in the selected literature.

Notably but unsurprisingly given the early stage of development of CE technologies, the ethics literature we found to be strictly relevant to ethical codes, frameworks and guidelines, often consisted of articles published in scientific journals. Our methodology still captured some grey literature as a few documents retrieved were in fact working papers.

Overall, we identified common research trends when scanning the experts' views on ethics of emerging technologies: 1) researchers would often outline the gaps in existing regulations, 2) they would then mention specific existing regulatory codes, frameworks or guidelines, and 3) they would either advocate for cross-fertilisation of existing areas (for example the life sciences and legal scholars and practitioners) or advocate strongly against them in favour of specialisation and expertise in specific areas, and finally, 4) propose novel approaches and present case studies of application of ethical codes, guidelines and frameworks to tackle the ethics of the emerging technologies.

Following the European Union experience of the emergence of Artificial Intelligence (AI) and its impact on society (Stahl, 2022), there was concern that ethics lags behind technological innovation for emerging technologies with high socio-economic impact. Ensuring that innovation and ethics co-develop is the primary motivation behind the TechEthos project. The hope is that the outcome of the analysis will allow us to feed into the development process of the climate engineering technologies, while their trajectory can still be influenced.

This is even more pressing, as we frequently found academics took a 'wild west' approach and issued guidelines that sometimes contradicted or did not consider existing laws and codes but innovated their own based on their particular research areas and expertise. Unlike a law, which requires the commitment of elected representatives, codes, frameworks and guidelines are produced in both academic and grey literature. Researchers in responsible research and innovation (RRI) are actively engaged in promoting and advocating for specific legal changes. This can create a representational bias (expert-driven) that is shaping both the technology as well as the ethical responses to it.

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