frontiers in Climate

PERSPECTIVE
published: 02 June 2020
doi: 10.3389/fclim.2020.00002

Social Science Sequestered

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Greenhouse gas removal (GGR) raises many cultural, ethical, legal, social, and political issues, yet in the growing area of GGR research, humanities and social sciences (HASS) research is often marginalized, constrained and depoliticised. This global dynamic is illustrated by an analysis of the UK GGR research programme. This dynamic matters for the knowledge produced and for its users. Without HASS contributions, too narrow a range of perspectives, futures and issues will be considered, undermining or overpromising the prospects for the responsible development of GGR (and threatening worse side-effects), and limiting our understanding of why and how policy demands GGR solutions in the first place. In response, we present policy principles for bringing HASS fully into GGR research, organized around three themes: (1) HASS-led GGR research, (2) Opening up GGR futures, and (3) The politics of GGR futures.

Keywords: humanities and social sciences, GGR research, marginalized, constrained, depoliticised, UK GGR programme, research policy principles

OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Negative Emission Technologies, a section of the journal Frontiers in Climate

Received: *28 February 2020*
Accepted: *29 April 2020*
Published: *02 June 2020*

Citation:
Markusson N, Balta-Ozkan N, Chilvers J, Healey P, Reiner D and McLaren D (2020) Social Science Sequestered. Front. Clim. 2:2. doi: 10.3389/fclim.2020.00002

INTRODUCTION

Greenhouse gas removal (GGR) techniques hold out the promise of removing GHGs from the atmosphere, at globally significant scales. GGR techniques are typically envisioned to have two explicit, inter-related roles in future climate policy. Firstly, to compensate for emissions that are especially hard to mitigate, e.g., some emissions from aviation and agriculture. Secondly, to subsequently reverse any "overshoot" of cumulative emissions above a safe limit (Royal Society, 2018).

The promise of future use of GGR techniques features in all the scenarios that underpin the Paris Agreement (Minx et al., 2018), having previously been increasingly adopted by modelers developing pathways to limit global warming to 2 or 1.5°C (Fuss et al., 2014; Beck and Mahony, 2018). Recently, several countries have committed to net-zero climate emission targets, for example, the UK and France by 2050, Sweden by 2045, Finland by 2035 and Norway by 2030, to be realized in part through GGR deployment or international offsetting (Darby, 2019; UK Government, 2019).

Some GGR techniques, such as afforestation, are in use, mainly for other purposes than climate mitigation, and far from at the scale envisioned in relation to current climate policy; others, such as direct air capture with carbon storage, are yet to be developed. There are large uncertainties and/or intense contestation as to their future use at scale, in terms of cost, effectiveness, resource availability, incentivisation, justice implications and acceptability among other aspects (Fuss et al., 2018; Minx et al., 2018; Nemet et al., 2018). The origin and form of policy demand for GGR has also come under scrutiny. Several authors have pointed out that betting on future GGR use is risky (Fuss et al., 2014) and also risks permitting a slower pace of emissions reductions in the short term (Anderson and Peters, 2016; McLaren, 2016; Markusson et al., 2017).

GGR brings together researchers from several pre-existing research communities, including modeling (Laude, 2019), carbon capture and storage (CCS), and land use (Minx et al., 2018). Minx et al. (2018) show that there are distinct and diversifying research fields mapping onto specific techniques, but at the same time increasing connectivity (shared references) indicating emerging common discourses. Some initial dedicated government funding (notably the UK GGR programme, £8.6m, 2017-2021) has also appeared in the last few years, and the first international conferences ("Negative CO_2 emissions" in Gothenburg, and "Negative Emissions: Integrating Industry, Technology and Society for Carbon Drawdown" in Canberra, both in 2018) have taken place. There is a risk that this emerging institutionalization locks-in problematic tendencies discussed below, unless action is taken. In this paper we argue that, to date, humanities and social sciences (HASS) research on GGR has been marginalized, constrained and depoliticised—like much other climate research (Hulme, 2011) and set out principles for integrating HASS into GGR research.

FROM CONTENTIOUS CLIMATE GEOENGINEERING TO INSTRUMENTAL GGR RESEARCH

The notion of GGR (alongside similar concepts like Negative Emissions Techniques, NETs, and Carbon Dioxide Removal, CDR) used to be seen, alongside solar radiation management (SRM), as one of two kinds of climate geoengineering (Royal Society, 2009). But recently, GGR is more often being presented and constituted as a research field in its own right. The IPCC's 5th assessment report (2014) made a distinction between GGR (specifically CO_2 removal, primarily bioenergy with CCS, BECCS) and SRM. Many models and scenarios included in the report used GGR to reach a 2°C target, some even at rates exceeding 20 Gt CO_2/year (see e.g., p1315), whereas the report enumerated the many risks of SRM (WGII Section 19.5.4) and excluded it from the scenarios. By the time of the IPCC Special Report on 1.5°C warming (2018), GGR was presented as entirely separate[1].

Despite heavily featuring modeling work, climate geoengineering research has stimulated a wide range of HASS contributions. For example, in the UK, the ESRC/AHRC funded project on Climate Geoengineering Governance, encompassed social science and humanities, including philosophy and law. This allowed for exploration of diverse issues such as problems of lock-in and path-dependence, and the impact of Confucian ethics on the social distribution of responsibility for climate change (Healey and Rayner, 2015). Among inspirations was the responsible research and innovation framework, emphasizing anticipation, reflexivity, inclusion and responsiveness, in earlier HASS geoengineering research (Stilgoe, 2015). From contrast, the emerging GGR field has a rather narrow range of HASS contributions, focusing heavily on instrumental questions of cost-efficient deployment modeling and public acceptance, more akin to CCS research (Markusson et al., 2012; Waller et al., 2020).

Whilst climate geoengineering research developed at arm's length to policy, the separate GGR research field is emerging in close interaction with climate policy making, and policy-oriented climate modeling, with consequences for how the field is constituted, what disciplines are included and how. Like policy-oriented climate change research generally (Hulme, 2011), *a narrow, instrumental, techno-economic framing dominates*, oriented toward answering the question: "GGR will be needed, how do we make it happen?", and approached through economic optimisation of anticipated GGR deployment as compensation for recalcitrant emissions and emissions overshoot (McLaren, 2020). Beyond that techno-economic core, the language is one of risks and co-benefits (mainly environmental, but sometimes also social, political etc.). Out of more than 130 papers presented at the Gothenburg conference[2], about 25% were purely technical studies, and about 40% were techno-economic studies, generally focused narrowly on cost implications (and led by engineers rather than economists). Less than 25% of contributions were from social scientists or economists, and very few from humanities researchers. At the Canberra conference[3] roughly 10 of the 30 presentations were socio-economic contributions. The UK GGR programme is dominated by the natural sciences (here including physical, environmental and engineering sciences), reflecting the call specifications of the funders (NERC, 2016). Whilst about 40%[4] of the participating researchers are social scientists in the broadest sense, approximately half of whom are economists, ten out of eleven projects (incl. all four larger consortia) are led by natural scientists. Humanities scholars are largely absent.

The UK GGR programme is also strongly focussed on policy makers as an audience. The research agenda is designed by and for them to underpin envisioned GGR deployment, and as a result tends toward the narrowly instrumental. The immediate UK GGR policy context contains the roots of the problem. For example, a prominent report (Royal Society, 2018) set out the technical potential of a set of GGR techniques, and has been influential on subsequent research policy. It deals somewhat with economic, legal and social issues, but overall the social dimension is reduced to one of limited public acceptability and understanding; the social understood as a mere barrier for deployment, and approached according to a long-discredited knowledge deficit theory (Wynne, 1991; Sturgis and Allum, 2004). Social science is not entirely "sequestered" and out of sight,

[1]The emerging distinction between GGR and SRM reflects differential uptake in climate policy discourse, rather than wholly distinct ethical and political issues, as both sets of techniques are responses to excess emissions. It is often said that climate geoengineering, and especially solar radiation management, is intrinsically more provocative than GGR, but what is and isn't controversial is not predetermined, and should not be decided *a priori*.

[2]http://negativeco2emissions2018.com/programme/

[3]https://negativeemissionsconference2018.wordpress.com/science-programme/

[4]We calculated this using a list of participating researchers at Programme start in 2017, and classified them by broad discipline using information available online. Note that this is a head count, rather than full time equivalents. It also does not readily translate into a quantitative share of funding dedicated to social science inquiry.

but given a very narrow role. This analysis draws heavily on the UK case, and whilst supported by the international conference data, there may also be differences among countries' emergent GGR policies.

WHY DOES IT MATTER?

Crucially, the work of social scientists tends toward particular roles and topics. Mapping[5] of the social science across the UK GGR programme shows that whilst the methods and the conceptual lenses applied vary, and there is some room for interpretative and critical social science (e.g. Markusson et al., 2018; McLaren et al., 2019; Waller et al., 2020; Pozo et al., in press), the problems to address are predominantly seen through a narrow, instrumental frame: as drivers and barriers. For economists, the main focus is on costs; for other social scientists, public perceptions and acceptance. More specifically, we identify three main problems:

(1) Calls to *integrate* knowledge using one narrow techno-economic framing seriously constrain what counts as relevant social science, and tend toward placing social scientists in *marginal* service roles, for example responsible for devising ways to predict or control public responses to GGR technologies. The roles of HASS GGR researchers should not just be providers of data on public acceptability to help construct new models or scenarios, nor be communicators of physical science results to lay publics or policy makers.

Scientists involved in the UK programme identified[3] as a challenge for their work precisely the need to integrate social science research with modeling and life-cycle analysis (LCA). This is unsurprising given differences regarding both epistemology (what counts as knowledge, e.g., qualitative methods) and ontology (what aspects of reality matter, e.g., power relations).

(2) The instrumental, techno-economic frame is *too constrained*, even when it comes to analyzing social dimensions of GGR deployment futures:

(2a) The dominating directions of GGR research do not reflect the urgency with which the techniques would need to be scaled up (Laude, 2019; Nemet et al., 2018), since they omit many cultural, political, etc. dimensions of plausible future "real world" application contexts, and so also narrow down what futures are considered. Such thin techno-economic accounts are complemented with HASS research that tends to get stuck on a limited set of questions including whether lay publics will understand and accept the visions of experts. For example, Lenzi et al. (2018) point out that despite the professed need for a massive rollout of GGR and the many value-laden aspects raised by implementation at scale, "there has been no systematic evaluation of the ethics of carbon removal methods by the climate assessment community or professional philosophers." Indeed, some of the rush to deployment without stopping to take heed of broader social and ethical considerations may ultimately undermine the instrumentalist agenda, as seen in backlashes over past efforts to deploy nuclear power or CCS (Barry, 2016; Asayama and Ishii, 2017).

(2b) In the dominating strands of GGR research, the way GGR futures are analyzed *as futures* is problematic. Scientists in the UK programme identified analyzing the deep uncertainty about the future(s) of GGR, in a context marked by lack of evidence and experience with these techniques, and uncertainty about the future societal contexts in which they may be deployed, as another key challenge. Again disciplinary differences matter, and it is hard to square a positivist focus on quantified estimates of error with qualitative understandings of ignorance and ambiguity (Stirling, 2008).

(3) Finally, the narrow, instrumental frame also tends to *depoliticise* GGR research, making many avenues of critical inquiry invisible, and research on them under-resourced. Legitimate questions about, for example, how we ended up proposing GGR in the first place, and how policy makers and modeling shape GGR research are not asked. Castree et al. (2014) commenting on Global Environmental Change research in the Future Earth programme, argued that without critical scrutiny of the current societal regime, climate research tends toward supporting the status quo. Castree et al. (2014) argued for environmental social science that depicts humans as diverse and often in disagreement—and crucially work on power, violence, inequality and alternative society-environment regimes—and an ensuing exploration of a wider set of means and strategies.

BRINGING HASS FULLY INTO GGR RESEARCH

We here set out principles for bringing HASS out of sequestration and into GGR research more fully, which also address the problems identified above, structured as three themes:

(1) *HASS-led GGR research*

To address the problem of subsuming HASS research under one dominating instrumental, techno-economic framing, we need to consider how GGR research is organized. HASS, offering rich and diverse theoretical perspectives and cultural insights, should be considered, respected—and in some cases lead—in the design of all GGR research. There is a need and opportunity for engagement across disciplinary boundaries, and with external stakeholders, and in various forms of processes and projects, in inter- and transdisciplinary work (Forster et al., 2020).

Yet there is also a need for HASS research on GGR that is organized independently from both the current policy agenda,

[5]We draw here on mapping of the social science research across the GGR programme, and documented discussions at two workshops for participants – aimed primarily at HASS researchers, but with a wider attendance – in the programme, organized by the two first authors of this paper. A published report from the first workshop is available here: https://www.upgreenlca.eu/assets/GGRT_SocioEconWorkshopReport_20180920_Final.pdf.

and the expectations of natural scientists and engineers. Independence from policy agendas is valuable not only for exploring alternative futures, but also for the very immediate and pragmatic reasons that policy agendas can change, e.g. after elections. The GGR futures in a 2030 zero-carbon strategy to progress toward Labour's Green New Deal would be different from those implied by a continuation toward the 2050 net-zero target set by the current Conservative UK government. Enabling independent HASS GGR research requires changes to current funding regimes and science policy. Current climate science funding dramatically under-supports HASS research (Overland and Sovacool, 2020).

The next two themes are about widening the set of GGR futures considered, and understanding why they tend to be narrowed down so much in the first place, respectively.

(2) *Opening up GGR futures*

(2a) The narrow techno-economic framing of GGR needs to be challenged, and opened up to a fuller range of disciplines and perspectives. As a first step, research about GGR framings is needed, to better understand the problem of it being narrowed down (Waller et al., 2020).

This would then open up for generation of knowledge about both descriptive and normative aspects of GGR that are poorly understood. Minx et al. (2018) point to a dearth of work on political economy, socio-economic contexts, social psychology, ethics and innovation processes. To this we might add aesthetics, spirituality and history. For example, ethics researchers may address questions like: if all the current and future generations were placed "behind a veil of ignorance," which generation is better or worse off by not taking actions today with the expectation that GGR techniques can solve this issue in the future?

And the visions about GGR provided by current policy makers and experts need to be complemented with others. In a time as politically turbulent as the current, there is surely need to prepare for the widest possible range of futures. This theme requires engagement with a wide range of actors with different ideas about what the future may hold.

(2b) Research is needed about the current circulation of GGR visions and promises, and about the processes through which they direct and shape development trajectories. This should include research about what assumptions about people, politics etc. are embedded in current visions for GGR. An important question is: what ways of relating to the future are embedded in GGR visions?

Doing research about GGR futures is hard, given the lack of evidence on their interactions with the environment and the wider society. We can't predict the future no matter how much science we do. And error bars are simply not enough to account for the deep uncertainties at play in potential futures. But there are other ways of doing research about the future/temporalities, which can complement traditional positivist predictive modes of knowledge production and so it is necessary to expand the disciplines brought to bear (Ozawa et al., 2019). The uncertainty of GGR futures is also compounded by possible interactions with the unfolding of other climate policy options. This includes social, cultural etc. interactions.

Sociology of science can contribute to this theme by exploring how knowledge about GGR is shaped by our current society. For example, how are current North-South relations reflected in scientific assumptions about biomass supply? But also e.g., innovation studies, with its sensitivity to complexity and open-endedness of innovation processes and social psychology, which seeks to test the assumptions of how individuals actually react to stimuli or how they might behave in simulated futures can help expand our understanding of the uncertainty inherent in GGR futures.

(3) *Politics of GGR futures*

To understand why particular ways of framing GGR have been used, and doing research about it, and why this may be hard to change, it is necessary to understand the history and politics of the *context* of GGR research.

Political economy research can clearly contribute here. It can go beyond existing research on who would win or lose out financially from implementing, or not implementing, GGR by taking into accounts the effects of merely talking about and developing GGR. Also, how are such interests constituted and able to shape emerging development trajectories? How are interests re-constituted by the pursuit of GGR?

This theme also opens up for broader questions about equity and justice (Pozo et al., in press). What are the generational, class, gender, race, etc., implications (and preconditions) of GGR futures, and why have these concerns not been taken into account (enough)? Under what conditions can such issues be handled well, and GGR development reinforcing current inequalities be avoided? And how can engagement with a wide range of actors help construct GGR futures that are less oppressive?

The politics of GGR is being (and will be) played out differently across scales and places. Geographically-informed studies of politics and justice are also needed in this theme. Relevant issues relating to North-South relations, race and class certainly have geographic aspects. And the costs and benefits of GGR techniques, and even the criteria by which they are assessed, will vary from jurisdiction to jurisdiction. The overall contribution of GGRs to climate action will be determined by these choices, expressed through Nationally Determined Contributions in the Paris process (Honegger and Reiner, 2018). There is an issue of epistemological justice here: countries in the global South need to be able draw on, and help determine the direction of, work in the global North, where currently most research on GGRs and their governance currently takes place.

Clearly, a historical perspective is also helpful to understand how the current predicament came about, and how current GGR futures originated. This includes then the recent, as well as longer-term, history of science policy (such as institutional changes in UK research policy and funding, the narrowly framed instrumentalities it may support, and the extent to which it is open to the role of critical enquiry from HASS research, and whether that is different in other countries). It also needs to look at the epistemological and policy privilege accorded to climate modeling in current GGR discourse, and all other fields contributing to the emerging GGR research community.

Finally, HASS research can in these ways help explore new ways of governing technologies such as GGR, in ways that more fully take into account what is best for people (and planet).

DATA AVAILABILITY STATEMENT

Some data is linked to in the paper - please see footnotes 2, 3 and 5. Beyond that, data is not sharable because of GDPR, or because it exists in working material format only. Any queries can be directed to the corresponding author.

ETHICS STATEMENT

This research was conducted according to the principles of local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

NM led the drafting of the paper, with contributions from all co-authors. NM and NB-O organized workshops and data collection about the UK GGR programme.

FUNDING

We acknowledge funding from the UK GGR programme, under several specific grants: NE/P019838/1, NE/P019900/1, NE/P019951/1, NE/P019668/1, and NE/P01982X/1.

ACKNOWLEDGMENTS

We want to thank participants in the two workshops for social scientists in the UK GGR programme, as well as those who helped us map the social science research in the programme.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.