

September 13, 2023

Dear Editors

We wish to state at the outset our overall pleasure with the detailed and quality reviews provided. Please see below our response to this robust sets of comments. Following each discussion point, we reply in *italics* with details on all changes now completed.

Sincerely,

Terre Satterfield
Sara Nawaz
Miranda Böettcher

REPORT 1

Thank you for the opportunity to comment on this important work.

As a project developer and the “social science lead” for multiple projects, I really wish that I would have had this paper a year ago. It contains many many helpful items. I am confident that the other social science leads I know at other project developers will feel the same. There really are many social science best practices contained in this chapter, so thank you very much for this work. I recommend that you publish it soon after receiving feedback and incorporating that feedback appropriately. At the same time, I look forward to a near future version that is written for the audiences you list and taking into account the feedback below.

We are pleased that you see this chapter as incorporating the wide array of best practices that exist and that you wish you might have had this sooner. That said, we do agree that materials for different (less academic) audiences are also urgently needed.

My top comments:

The paper overall assumes that the activities take place in a research fashion. In the world today, social science research does not have enough funding to move us ahead

at the pace that is required by the depth of the climate crisis. We will need to enable projects that are linked with small scale test deployments. The best practices listed here seem to be targeted at researchers rather than employees of OAE companies that will end up implementing these solutions. The companies that will be funding these are severely limited in resources: time is always short, trained social scientists are essentially non-existent in the company and industry generally, and money is not typically allocated in significant amounts for social science and community engagement on these projects. Perhaps in a future version, you can create best practices for OAE community engagement for OAE practitioners. This would include references to quickly understandable base content, concrete tips on the best practices to apply in different situations, and case studies of successes and challenges that have occurred in projects.

While the mandate for this chapter and the journal special issue is to target researchers, we do agree and share your concern about 'what companies need' (such as those operating in early-stage deployment contexts). This is, as you also note, particularly key when funding for the social sciences is poor to absent. We have and will continue to work toward a more practical set of guidelines, in a separate endeavour. We hope also that the 'key messages' content along with a focus on very specific steps to conduct at different stages or to characterize particular sites for OAE trial help toward this goal. In the end, you are right to suggest this as both a problem of funding and a problem of who will do this work. Often it might be done by small company principles, but it might be graduate students entering this field (a growing number) and so talent will become more widely available.

One concept that I did not see in the discussion is the concept of scale and length of project. What are the differences in best practices during very early testing versus evaluation versus pre deployment? Considering this concept throughout the document would lengthen it but provide significant value.

This is a good point and our review now addresses scale in two ways: (1) scale as in stage of deployment and (2) as in volume of removal involved (say 2 MT scale). We hope we have covered the first meaning in table 1 where we designate or link the methods covered to the applicable stage of deployment. Also, in the section under 'engagement methods in brief,' methods are now more fully elaborated. The other definition is key and two of the authors have recently conducted some work that sought to explore thinking about scale with public group regarding three mCDR approaches. Our initial findings are that exploring scale has proved highly difficult. The closest equivalent literature that we're aware of is work on [numeracy and psychophysical numbing](#). More generally, issues of scale are in our view a key (methodological) challenge to address for public engagement on OAE and carbon removal

The mandate for this chapter was earlier stage OAE research, but we do still think that some mention of this problem is very key and so have added text within the section entitled: "Be transparent about the full potential scale of OAE deployment." That new text now reads: Ideally, engagement activities should provide participants with what OAE might look like at scale—not just with regard to an individual project's small field trial. While it may be tempting to only engage people on their views regarding very small-scale activities, it will be critical—for both ethical and pragmatic reasons—to explore views on larger scale implementations. It is well known that understanding large scale events such as humanitarian disasters is difficult if not beyond comprehension (Slovic 2007). But this does not preclude the potential usefulness of comparing OAE at the 2 MT scale as compared to the production and storage (sinking) of macroalgae or the use of offshore direct air capture and storage at similar scales. This would likely throw both social preferences and likely tradeoffs into relief by introducing considerations such as shipping (to gather, bundle and sink macro algae), or drilling (to store CO2 in offshore basalts)."

The paper doesn't include a section discussing how to respond to concerns that have nothing to do with a specific project. For example, in many communities, some people are likely to be opposed to CDR generally, or are climate deniers, or feel that CDR should go ahead in only a "nature based" approach like reforestation. Having a section describing how to respond to those concerns would be positive.

Yes, this is a significant problem for all social engagement work. We generally consider this a 'values' conflict and as such, the best approach is to try to delve further with communities into both their value positions and what these mean for assessment and decision making. We have added text on converting values to 'performance measures' in the context of public engagement. And we think comparing technologies at scale do reveal some of the fallacies of nature-based commitments. [See above point on 'at-scale']. While the scientific community is starting to produce these comparisons, there is literally no social research on perceptions of scale and how this affects social license to proceed.

There is a complex interplay between the communities of any project and the appropriate regulatory bodies. Project opponents and supporters both interact with the regulator to influence the decisions made by those groups (although it is typically the opponents who spend the vast majority of time in contact with the regulator). Sometimes the regulatory bodies are not viewed by the community in a positive light, and trust is low. The piece could benefit from more coverage on how to effectively work with regulators and the public.

Yes, and we have all had some experience that way in different research contexts. It is the case that trust is key, as you note, and so we have made the following changes to the manuscript to better reflect this. In section 3.2 on small group approaches, we have added content on building trust using the example of co-production of regulatory frameworks between (local) administrators and publics as essential. This can be facilitated by ongoing and iterative engagement formats of the kind covered here (e.g., scenario workshops) that involve the regulators as well as members of local publics. We have also pointed to some relevant literature/best practice guides from other areas (e.g., wind farm development, fisheries, or urban planning)?

One of the primary ways that communication happens from a project developer to a group of people is through the media - print, radio, TV, social, blogs, etc. The paper would benefit from a discussion of how to integrate a communications plan with a community engagement plan.

*There is a field of risk communication that has thought deeply about this. While beyond the scope of this chapter, we did in fact select methods that many risk communication scholars endorse precisely because their 'two-way' communication approach. For example, all of the small group methods mentioned here take this mandate very seriously and some (decision analysis) convert what is learned in that communication to explicit decision-relevant objectives and measures. We have also added some sources to at least offer some useful suggestions and to explain several common errors when treating risk understanding as a literacy problem alone. We have found the following sources particularly useful: Fischhoff, Baruch. "Risk perception and communication." *Risk analysis and human behavior* (2013): 17-46; Kahan, Dan M. "Climate-science communication and the measurement problem." *Political Psychology* 36 (2015): 1-43.*

General knowledge on climate, CDR, ocean CDR, and OAE is low in many communities. The paper would benefit from a discussion of determining the level of knowledge and then practical advice on how to integrate effective education material for the community. Are there sources of OAE education material available? How should it be created?

As with the recognized need for communication expertise, educational materials are out of scope of this work. But they will become available near term, we hope. It is our understanding that a great deal of thinking goes into designing these materials for engagement, but little or no testing of these is complete. That is, the state of the field is simply at the level of introducing very simple definitions. Both academic and NGOs are starting to develop tutorials, which can be modified for different needs. Unfortunately, [a recent report confirms](#) limited support of OAE as compared to other ocean NETs, a finding reported in the chapter. This may change as knowledge improves as we now know, via same

report, what is currently known or mentioned by public groups from a knowledge POV. They also find that people “hardly discuss the need to remove CO2 from the atmosphere” indicating that “the concept of negative emissions” itself seems difficult to engage with. In sum, we agree that knowledge is low and that educational material is needed. We also make this point explicitly in the chapter

Overall, the paper is a good set of social science techniques that can be applied to OAE projects. I believe a more appropriate title would be “Social Considerations and Best Practices to Apply to Engaging Publics on OAE.” This paper lists many great social best practices that have been created and applied in other circumstances. However, these aren’t OAE Engagement Best Practices. They are social best practices that can be applied to OAE. We do not yet have enough case studies of OAE project development to determine which of the different social science practices can be called best practices in the new realm.

Yes, this is a fair point and it’s true there aren’t any best practices for OAE, they are imported so to speak from reasonably equivalent contexts. We have changed the title accordingly and appreciate the wording provided.

Based on your summary, the primary audiences are social science leads, natural science and engineering leads, and funders. The paper seems to be written with a primary audience of social science academics. Changing that would be a huge undertaking and I don’t recommend trying to do that now. I do know a few writers who specialize in creating public facing (non academic) books based on complex techniques if you are interested.

Yes, we would absolutely be interested in that option/reference, thank you.

Detailed comments:

Line 47 talks about societal perception. Line 50 talks about deployments introducing negative consequences. Switching from perception to actual consequences is confusing to me.

Thank you, we have changed the wording to make these points more discrete as one is about perception, the other actual consequences.

Line 80. My perception is that all ocean CDR is deemed more risky than land-based CDR generally. If there is data to support that perception, it would be nice to note it here.

We have some data on this under review, so cannot refer to it just yet. But overall, the same technology on land v. ocean (e.g., carbon storage in basalts) might be viewed more favourably but there is a lot of variation across terrestrial and marine CDR. But we have added a reference to that line to distinguish the differences across mCDR – a paper that was not available at time of original submission.

Line 83. Is there data to suggest that the approach mentioned will backfire in the case of OAE? I agree with you, but data would be nice.

Yes, the classic Fischhoff reference applies and is within, but we have also added the more recently classic and very readable work in a climate change context by Kahan. Kahan, Dan. "Fixing the communications failure." Nature 463.7279 (2010): 296-297.

Paragraph starting on line 149. It is very difficult to separate actual engagement from pure research. While there are some activities related to sensing the position of a community and some to planning that might be able to be done in mostly a "research" capacity, most can be done only in conjunction with a real project. Is it possible to suggest more strongly that community engagement should be a part of all OAE (and all ocean CDR) projects.

Yes, we agree entirely with the importance of this message and have modified that paragraph to strengthen this claim. We have also added a new reference that makes this point strongly.

Section 2: line 158

The sentence structure starting on line 165 feels a little confusing to me.

Yes, understood and we have clarified wording

Line 216 contrasts evaluation of risk by "most people" against line 219 that defines risk by scientists or risk assessors. Defining risk is very different than evaluating risk. Have you considered contrasting how most people evaluate risks against how scientists or assessors evaluate risks?

Thank you, we clarified the language to make it clear that the point here is that the two are often at odds: that is, what public groups think and what experts think and how each 'evaluates' potential harms.

Do you have data to support the sentence in line 256-258? If so, it would be an important note. If you don't have data, it's a good thing to consider.

We agree, and there is work on this underway, but currently this discussion paper cited is the best available consideration of the problems of 'nature-based' framing.

Do you have data for the sentence in 285, .."Similarly, distributional justice will be of primary concern..."

There is a wide body of survey research toward this end, but we have added data specific results recently reported by Jennifer Carman and colleagues

Section 3 line 457

Line 475. It has proven very difficult to engage with any community in the abstract. It is possible to survey different groups and so perhaps get a feel for their biases and predilections. However, without a specific proposed project to motivate a real conversation, we have not found individuals to take a conversation seriously enough. Further, because so much effort is required to determine a potential site, engage the regulator, engage local communities, etc., it is very time consuming and resource intensive. For most OAE project developers before 2027, it will be very difficult or impossible to take on the cost in terms of time and money and be able to leave an area without having completed some project work. In other words, companies working in this area much choose a project site and then engage with the community, not the other way around. Perhaps consider a strong recommendation to due at least a cursory evaluation of the history and social considerations of a site before committing any kind of significant resources.

Agree, added a sentence to this effect using the language provided here

Line 481. How do you effectively describe/define the local area? Generally, how does one define the community(ies) that are affected by a project. Is it just people near the beach of the project? Is it recreational users of the area? Businesses in the town over that might be affected? Who gets to say who is in the "affected community?" This is an area that needs more discussion. Saying "it is whomever considers themselves affected" is dangerous - that invites people activated in favor of or opposed to the project to insert themselves even if they are from far away.

We also do not subscribe to an 'whomever' answer to what is local. The key here is to recognize local jurisdictions. That said, in most cases people who see themselves as affected' reveal themselves and articulate the knowledge they have about how they might in fact be affected. This is not often visible to developers or regulators. We also agree that it is common for distant actors to become involved. But they do not generally have 'purchase' unless they articulate localized concerns. The most important step here is to build alliances early and often with known actors. Oceans are also often seen as being a very large public good, and so we wish to avoid making strong claims about who is affected, aside from direct physical or social effects on communities

Counter to this, any alkalinity changes will likely be undetectable even a small distance away from the actual project site, and this is likely the case for a number of years from now. If the alkalinity is not detectable at a specific site even by the most sensitive instruments, and likely won't be for years, how much weight should be given to the members of that community?

Yes, this is true. But it may well be the case that (and I think a primary message here is) operators are dealing with problems of perception. This is perhaps why alkalinity measures are much less important than might be the source of materials or the shoreline infrastructure involved.

Line 491. "Vulnerable groups." Vulnerable in what way? Ocean alkalinity is well understood. It is benign at small doses. There are no known allergies. Who specifically might be harmed?

Social scientists generally refer, here, to those often not considered in decisions that will ultimately affect them disproportionately. Who, for example, might experience significant impacts associated with otherwise small changes (e.g., housing pressure and cost due to an influx of workers installing a facility). By way of example, in coastal areas in Canada this might be First Nation communities, along shorelines it may displace existing residents. We have clarified the wording to designate this as references the relationship between consequences of actions and decisions and not health impacts per se. Relocation, as per above example, might be a bigger concern. See lines 494-509 for wordin changes to this effect.

Line 527. Please add a period at the end of the sentence. Consider rewording the sentence - the structure is a little awkward.

Yes, thank you, done.

Line 516. Section 3.2. This is a good list. Have you considered providing advice on the order that they should be deployed to the community? It's unlikely that companies will be able to deploy all of the section here before "engaging" in the community using techniques listed in the section starting on line 593.

Yes, agree, detail on applicable timing or stage of development for each method is now in Table 1

Line 593. You have two section marked 3.2. This also applies to line 630 which should be 6.3.1, line 679, line 714, 750, 809, 876, 939.

Thank you, corrected

Line 601 - 611. Similar question to the question above about who the community is? There is likely to be a group of people who is relatively more concerned and will want to be engaged, perhaps to delay or stop the project. How to ensure a reasonable cross section of participants?

Yes, there is content on sampling for each, but when working with a local partner, deferring to their expertise on cross section of publics is often the primary source.

Line 617. Could you explain "integrating values, impacts, and concerns"? Is there alternative language you could consider?

Agree, and yes done.

Line 620. Period at end of sentence.

And, yes, done, thx.

Line 819-828. The scale of the project is somewhat in question in this section. For example, if a pilot OAE project is the size of two shipping containers, how much tax revenues should be shared with the community? How many employment opportunities are appropriate? It may be the case that a pilot DAC facility, which would likely cost hundreds of millions of dollars and be acres in size, is significantly smaller than a pilot OAE project. How does that affect what should the community expect in an engagement plan?

We are not able to link this comment to those lines or section? I don't disagree that these are questions that needed answer and we hope that comes through in sections where we

offer suggestions as to how and what questions to consider in all engagements with local groups. That is, we see these as questions, ideally, to be worked out in the context of engagement as they are very context specific. It is difficult to imagine, for example, assigning a priori the proportion of tax revenues that might be appropriate. But we do take the position that things like benefit-sharing agreements should take place in the early stages so that any such benefits can be anticipated. They don't need realizing at early stages, but being clear and honest about what would occur if scaled up is key to public trust.

Line 897-8

"...goal is to elicit or initial heuristic responses..." I think the "or" is not meant to be there, but if that's not the case, I don't understand the sentence

Yes, you are correct, word removed. thx

Line 924, I suggest adding a comma between "to unpack that" and "given additional ..."

Thank you, done

Line 931. Have you considered reducing the number of times that superlatives are used. For example, "always key" in this line. It's fine to say "key to the representativeness..." In my view, "always" doesn't add value in this context.

Fair enough, more bad habits than implied meaning. Superlative removed

Line 939 - there is recent work on a "faster" version of deliberative polling that is being done by Pete Weber (let me know if you would like an introduction) in California that aims to dramatically reduce the amount of time, effort, and cost of deliberative polling. This version is a cross between polling with no education component and multi-day deliberative polling and can be used early in the process.

Yes, that would be great. I tried investigating this but didn't come across the work. It would be nice to add some options toward this end

Line 971. Insert “gather” or “create” or “have” between “might” and “greater”

Thank you, edited using “might produce” ... and corrected punctuation

Line 978. The definition of “affected communities” is frequently unclear in OAE projects. How wide does the community reach? In the case of “offshore” OAE, where are the affected communities. Perhaps an entire section on how to effectively define “affected communities” in conjunction with potential communities would be a good section in this document. This is one example of my comment at the very top of the document (Comment A)

We agree that this is a thorny sampling problem, and struggled with this in the first draft. But across the literature this is extremely variable and, as with the above comment, this is very context specific. And so, it is difficult to discern who this is in advance. This is why we defaulted to questions to ask in the ‘doing your homework’ section, rather than also providing answers to those questions. But if you have other suggestions, we are certainly open to those.

Line 1007. Starting with “(3) incorporation of specific...”

It would be wonderful to include concrete tips here of how to convince a broad range or a small set of community collaborators to agree to spend their time with the project team in a collaborative way. People in the community are busy and time is scarce. In our experience, most people who are willing to put time in are opponents who do not want to collaborate.

Yes, this is both true and difficult. Interesting, some of the best suggestions on how to motivate this come from the ‘open innovation’ community and so we have added a reference to that and many recommendations do exist. There has also been some writing on this from people who work on ‘citizen science’ projects, so we’ve added that source as well.

The fact is, often practitioners hire ‘panels’ from survey research firms or marketing firms. But this can get very expensive and involves other problems. Overall, the ‘advice’ in the existing literature is much more about how to collaborate, less so suggestions on how to enable that.

Line 1019

Are CBAs appropriate in early stage OAE trials? The eventual impact to a community is not going to be large - there are not likely going to be huge plants built in a community for example. What size of a plant is required for a CBA to be appropriate?

Yes, this is similar to our above point. Conducting CBA is definitely not an early-stage reality, but proposing these possibilities might make sense. Even the DOE recommends being clear, early, as to what these might be. We hope that our wording, which emphasizes 'beginning the conversation early' makes sense, even though such analysis is premature on one level. makes sense as wording this way.