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Emily Cox[i] *Finn Müller-Hansen,*[ii] *William F. Lamb,*[ii] *Tim Repke,*[ii] *Rob Bellamy,*[iii] *Sarah Lück*[ii]

[i] *University of Oxford*

[ii] *Mercator Research Institute on Global Commons and Climate Change*

[iii] *University of Manchester*

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Chapter 6 | Perceptions and communication

Understanding the perceptions of publics, adopters and interested parties is crucial for implementing carbon dioxide removal (CDR) and for mutual learning. The CDR perceptions literature and analyses of social media and news media coverage yield lessons for responsible communication.

Key insights

- Involving a diversity of actors in CDR is both an opportunity for mutual learning and a challenge for communication.
- A growing literature on public perceptions highlights low awareness but nuanced attitudes towards CDR methods in studied populations.
- Key factors driving public attitudes towards CDR are perceptions of "naturalness" and ecosystem impacts, along with underlying values and beliefs – including about climate change. Evidence is mixed on whether the level of perceived "moral hazard" or people's proximity to developments influence attitudes.
- Twitter/X users and news media tend to focus on particular CDR methods in particular countries – for instance, soil carbon sequestration in Australia, peatland restoration in the UK, and direct air capture in the US.
- The level of attention given to CDR on anglophone Twitter/X in 2022 was similar to that in 2021, with generally more positive sentiment towards familiar and conventional CDR methods than to other methods.
- Coverage of CDR in English-language news media has strongly increased, especially since governments started to put forward net zero targets. The news media tends to conflate CDR with avoided emissions and mitigation approaches.
- This chapter identifies seven key considerations for responsible communication about CDR, developed from lessons from public perceptions research.

This chapter combines multiple sources of evidence to understand public perceptions and communication about CDR; these sources include surveys, experiments and deliberative approaches in the scientific literature, and data from social media and news media. Section 6.1 explains the role and importance of public perceptions, and Section 6.2 presents four complementary approaches for assessing perceptions of CDR among different groups of people (see Box 6.1). Section 6.3 summarizes the outlook for this topic, including knowledge gaps and how future assessments can build on this analysis (see Box 6.4).

6.1 The role of public perceptions

Understanding public perceptions is crucial for the ethical and effective development and deployment of CDR.

Public attitudes towards new technologies can have a crucial influence on their development and deployment.[9] Perceptions of CDR methods among interested parties and the wider public will influence prospects for scaling up CDR. Publics perform several key roles: influencing policy mandates, determining whether a project has "social licence to operate" on a local and/or national scale, and providing "demand pull" for new innovations.[232–234] In addition, the public can act as a direct stakeholder in many contexts – for instance, as landowners deciding whether to take up or allow CDR initiatives on their land; as a directly impacted community; as a community of interest in support or opposition; and as providers of crucial information on local, historical and social context, which may otherwise be lacking. Publics are an essential source of knowledge for developing more effective and responsible CDR policies and methods.[235,236]

Examples of the importance of public perceptions include the genetic modification of crops and food in the EU, where early public perception research identified serious issues with public trust in political and regulatory structures – lessons that later came to be seen as "remarkably prescient" in the wake of the EU moratorium on this technology.[237] Experiences with carbon capture and storage projects around the world show that some benefited greatly from lessons learned from earlier public successes and failures.[238]

But publics are not simply a source of potential opposition; they also play a crucial enabling role, for instance as advocates or as market actors. Public perceptions should not simply be seen as the end of the innovation chain (see Chapter 1 – Introduction), nor should researchers simply ask whether people "accept" an innovation that has already been developed. Instead, the aim should be early and continual two-way communication and reflexive engagement throughout the innovation process.[239–241] Publics play crucial roles throughout this process, as well as informing the overarching social and political landscape in which CDR sits. Participatory, deliberative approaches to decision-making can help ensure that informed views from a variety of perspectives are taken into account, which in turn can improve the quality and legitimacy of decisions, as shown in US work on shale gas development, for example.[242]

Box 6.1 Multiple sets of evidence for assessing perceptions of CDR

Different techniques for assessing perceptions have specific advantages and disadvantages and are rooted in their own sets of assumptions. Section 6.2 presents four complementary approaches for assessing perceptions of CDR among different groups of people: (1) a systematic map of the scientific literature to understand the current state of evidence on different aspects of public perceptions and CDR; (2) a qualitative review of this literature to understand *why* people respond in particular ways; (3) analysis of posts on Twitter/X to understand public communication on social media and how it evolves over time; (4) analysis of news media to understand key aspects of how CDR is communicated to wider audiences.

Who is "the public"? Different approaches to gauging public perception can define *the public* in different ways, and the definitions of related categories – such as s*takeholder* and *expert* – are also not fixed. This report presents findings relating to all three of these categories, differentiating where possible, although the boundaries are frequently blurred. People also operate from different positions – for instance, *professional* actors or *civic* actors – at different times, depending on the context.[243] This report uses *interested parties* as an umbrella term to include adopters of CDR technology, CDR experts, directly affected communities, and people with a professional interest in CDR. Although this term is imperfect, it serves as an overarching term to refer to all the groups studied in the systematic review. *Adopters* refers to those adopting CDR in situations where they have some jurisdiction (e.g. landowners, farmers, community/project developers). *CDR experts* refers to those with pre-existing knowledge and opinions about CDR, such as academics, policymakers, NGOs and industry professionals.

Elicited versus non-elicited information. Elicited information is asked for or drawn out by researchers, for instance using surveys, experiments and deliberative approaches. Non-elicited information is provided unprompted, for instance in social media posts or news media articles. Elicited approaches allow the researchers to control and analyse the context and participants, but they leave the results susceptible to framing effects created by researchers in the way the topic is presented to participants. Non-elicited techniques are based on statements by people who may already have an interest in CDR, for instance as part of their job or gained from their peer group, which will impact their views. On social media it can be difficult to disentangle whether participants are experts or professional communicators, a challenge this chapter attempts to tackle with a new analysis to identify user types.

Changes since The State of Carbon Dioxide Removal 1st edition. The assessment of public perception and communication of CDR has been strengthened since *The State of Carbon Dioxide Removal* 1st edition in the following ways:

- A new systematic review of the scientific literature up to May 2023, using an extended set of keywords and machine-learning techniques to identify papers (including expert perceptions papers), distinguishing between CDR experts and the general public

- A new qualitative review of papers on public (non-expert) perceptions up to September 2023 to understand why people respond in certain ways
- Updated Twitter/X analysis to end-2022, including new data on user types and posting frequency
- New analysis of news media

Box 6.2 Methods: Evaluating the state of knowledge on CDR perceptions in the scientific literature

Systematic map of the literature. In this analysis, the English-language scientific literature was searched using two databases (Web of Science and Scopus), and all studies that evaluate perceptions of methods that capture and store carbon dioxide were extracted. A much larger body of literature was identified than in *The State of Carbon Dioxide Removal* 1st edition, due to four main factors: (1) use of more comprehensive keyword searches and machine learning to identify relevant papers; (2) extension of publication date criterion to May 2023; (3) inclusion of literature on CDR expert perceptions and media analyses on CDR; and (4) inclusion of papers that do not mention CDR explicitly but talk about methods, such as biochar applications, that are considered to lead to net removals from the atmosphere. Decisions over point (4) are particularly challenging, with blurred lines in categorizing papers as being about CDR versus about methods that may capture carbon as a co-benefit; such decisions can lead to very different findings regarding the size of the literature and have also been encountered in the CDR policy literature (see also Chapter 5 – Policymaking and governance).[244] This challenge is especially salient for methods based on the management of natural systems, such as forest management and peatland restoration.

Qualitative review. The goal of the qualitative review is to understand why public groups hold certain views about CDR. For this analysis, the English-language peer-reviewed literature was reviewed for mentions of factors driving public attitudes: that is, attributes of the respondent or project that might influence how CDR, the specific method or the proposed implementation is perceived. Conditions for deployment (i.e. under what conditions CDR methods or proposals might become acceptable) were also examined, because support for novel interventions is likely to be fragile and conditional. A systematic search was conducted for papers published before September 2023 about public groups (i.e. local communities, adopters or the general public in a particular location, but not experts), perceptions (i.e. presenting empirical data), and CDR (not including methods where the carbon sequestration is a side benefit, or carbon capture and utilization from point source emissions). The search terms used in *The State of Carbon Dioxide Removal* 1st edition were also used here (see also Waller et al., 2024[245]), and relevant papers were added if they were missed with these search terms but identified in the systematic map. The identified papers were manually coded by reading the whole paper and applying a scoring system, based loosely on the IPCC evidence/agreement scales.[246] Papers were given two scores:

Provision of empirical evidence for the factor or condition:

- 1 = yes
- 2 = no

Certainty of evidence:

- 3 = strong evidence
- 2 = mixed results (e.g. where different tests within a single paper show different outcomes, or where deliberative participants were split)
- 1 = weak or no evidence (e.g. non-statistically significant results or low effect sizes)
- −1 = the inverse relationship (where the direction of the relationship is the inverse of the expectation or hypothesis; see Figure 6.2)

6.2 Existing evidence base

Among the studied populations, people are generally cautiously supportive of CDR research and deployment, conditional on factors such as environmental safety and personal values and beliefs. Communication about CDR on Twitter/X and in news media has strongly increased over the last decade, with specific countries tending to focus on specific CDR methods.

Overview of the perceptions literature

Perceptions of CDR is a much more studied subject than was indicated by the literature review conducted for *The State of Carbon Dioxide Removal* 1st edition. This is due to the broader search criteria and more systematic methodology applied in this edition (see Boxes 6.1 and 6.2). The overview of the literature in this report includes studies on general populations, affected communities, potential adopters of CDR methods, and CDR experts (e.g. policymakers, business representatives, scientific experts), enabling the report to differentiate between different types of actors (see Figure 6.1, bottom right panel). This systematic search of the literature identified 165 English-language scientific papers on CDR perceptions.

Even though the evidence base in this report is much larger than in *The State of Carbon Dioxide Removal* 1st edition, several key conclusions from the first edition remain valid:

- The majority of publications are from Australia, Europe and North America.
- Among the studied populations, awareness of novel CDR is much lower than awareness of conventional CDR (see Chapter 1 – Introduction, for definitions).
- Support for research and deployment among studied groups is generally moderate to high, depending on the specific CDR method.

The 165 studies identified differ widely in their subject matter, data and methods used, as well as geographic location (see Figure 6.1, top and bottom left panels). This report finds evidence relating to a variety of different CDR methods. Some of the earlier studies use the broad framing of *geoengineering* without naming specific CDR methods; the more recent studies often include several CDR methods and increasingly cover novel approaches.

Alongside research on public perceptions of CDR in general populations (65 papers), this report identifies an even larger body of literature on CDR expert and adopter perceptions (89 papers). Most of the research employs quantitative methods such as surveys and survey experiments, but there are also many qualitative studies using semi-structured interviews, workshops or focus group discussions, as well as some mixed-methods approaches (see Figure 6.1, bottom right panel).

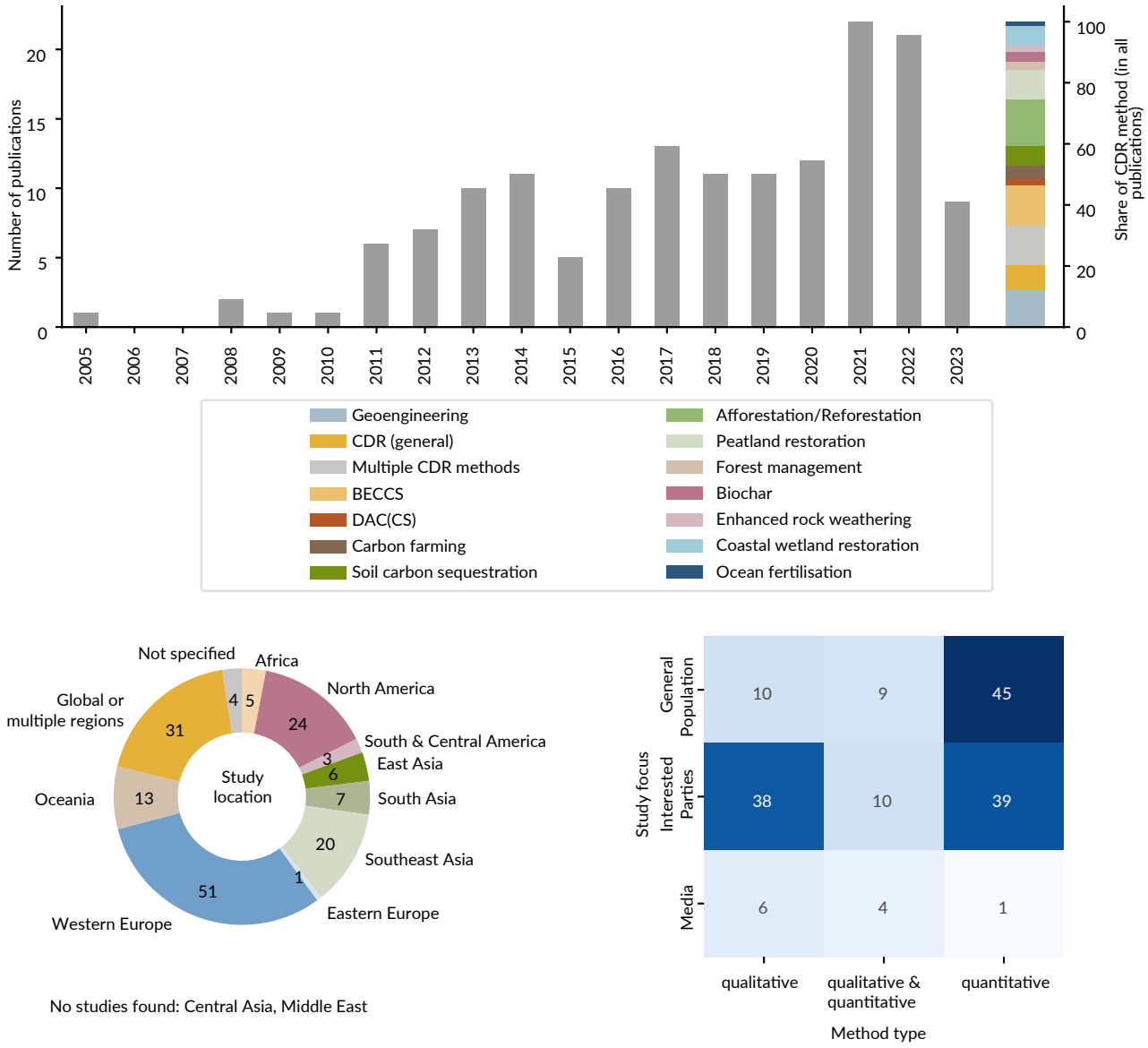


Figure 6.1 *Overview of the public perceptions literature on carbon dioxide removal (CDR) from the systematic map. Publications by CDR method and year (top), study location by region (bottom left), number of publications by study focus and method type applied in the study (bottom right). Carbon farming here refers to a cluster of CDR methods that can be applied in agriculture such as soil carbon sequestration, biochar and agroforestry. BECCS = bioenergy with carbon capture and storage; DAC(CS) = direct air capture (with or without carbon storage).*

Despite the much broader search criteria in this edition of the report, the geographic concentration in Europe and a few other countries, such as Australia and the US, remained: 62% of the studies focus on Europe, North America and the Pacific region (see Figure 6.1, bottom left panel), although the inclusion of studies on interested parties led to a higher overall coverage of regions than in the first edition. This concentration is likely driven, at

least in part, by the English-language-only search strategy as well as by the concentration of authors in Western countries. In the literature on CDR experts and media, many studies do not have a specific geographic focus but are geographically constrained by language or availability of study participants.

Studies report low to moderate levels of public awareness, familiarity or knowledge about CDR. Surveys often find low familiarity with many CDR methods, with afforestation/reforestation being the most known method.[247–249] However, it is difficult to compare numbers on public awareness, familiarity and knowledge because the number of papers presenting such data is still low, and studies often measure these factors in very different ways and report aggregate results differently. An immediate implication of low familiarity is that people's opinions expressed in surveys might be very susceptible to change.

Most of the quantitative studies focus on measuring attitudes towards CDR, often using measures of support or acceptance of CDR research or deployment. CDR methods that are perceived as "more natural" get greater support among the studied populations.[248,250,251] Other important factors influencing the degree of support are perceived trade-offs and co-benefits, costs, trust in institutions, and concern about climate change; these factors are discussed further in the next section. A smaller number of studies also look at willingness to adopt or willingness to pay for CDR.[252–254] Closely related to overall attitudes are the perceived risks and benefits of CDR. While most study participants see the benefits of CDR in regulating the climate through carbon sequestration, this is not necessarily the most salient benefit to them.[255] Risks that impact the perception of CDR include technological risks (e.g. the safety of underground geological storage), environmental impacts (e.g. on biodiversity) and social impacts (e.g. on local communities).[256]

The studies researching perceptions of interested parties can be divided into two sets: one that focuses on surveying or interviewing potential adopters of conventional land-based methods such as farmers and landowners[254,257,258] and another that focuses on experts such as policymakers, delegates in climate negotiations, researchers, and industry and NGO representatives. The latter set includes studies of expert perceptions of the potential and feasibility of CDR methods[259,260] and investigations of perceptions of policy-related questions, for example on the use of bioenergy with carbon capture and storage (BECCS) in future mitigation scenarios.[261]

Factors driving attitudes and conditions for deployment

As well as understanding *what* public groups think about CDR, it is important to understand *why* they hold such views. This understanding can enable policies and projects to be crafted in ways that are more in line with public preferences and that therefore potentially have lower risk of failure. To gain such insights, this report presents a qualitative review of the English-language literature on public perceptions of CDR, expanding and updating the review presented in *The State of Carbon Dioxide Removal* 1st edition and focusing only on perceptions of the public, communities and adopters (see Box 6.1). For this reason, the corpus of literature is smaller than in the systematic map, which also included papers on expert perceptions, papers on media analysis and papers not explicitly focusing on CDR.

For the qualitative review, the more targeted corpus contains 56 papers: 32 using

quantitative methods, 16 using qualitative methods and eight using a mixed-methods approach. Eleven of the new relevant papers have been published since *The State of Carbon Dioxide Removal* 1st edition. These largely represent an incremental continuation of existing knowledge, including testing whether CDR negatively impacts emission reduction efforts or intentions, via a "moral hazard" effect;[262,263] exploring the influence of climate beliefs and sense of climate urgency;[263,264] exploring preferred attributes of CDR;[265–267] and exploring how opinions change in different geographical contexts.[243,268] Direct air carbon capture and storage (DACCS) seems to be emerging as a key focus in the literature, as does new work on novel marine methods such as ocean alkalinity enhancement.[263,264] This section looks at the findings of the qualitative review to shed light on why people might form certain views about CDR (see Box 6.2).

The published literature identified 14 distinct factors driving public attitudes and 12 distinct conditions for deployment, as shown in Figure 6.2. There are many more papers exploring factors driving attitudes than exploring conditions for deployment. Survey and experiment papers tend to provide evidence on factors, whereas qualitative papers and papers on landowner uptake look at both factors and conditions. Some indicators could fall into either category; therefore, the full text of the papers was reviewed to determine how the findings are described in the paper itself. The largest body of evidence, by number of papers published, is on whether something is perceived to be "natural" or to "mess or tamper with nature", followed by whether it is perceived to have "ecosystem impacts" (including impacts on wildlife and biodiversity, as well as broader environmental impacts).

We can understand *why* publics respond to CDR in certain ways

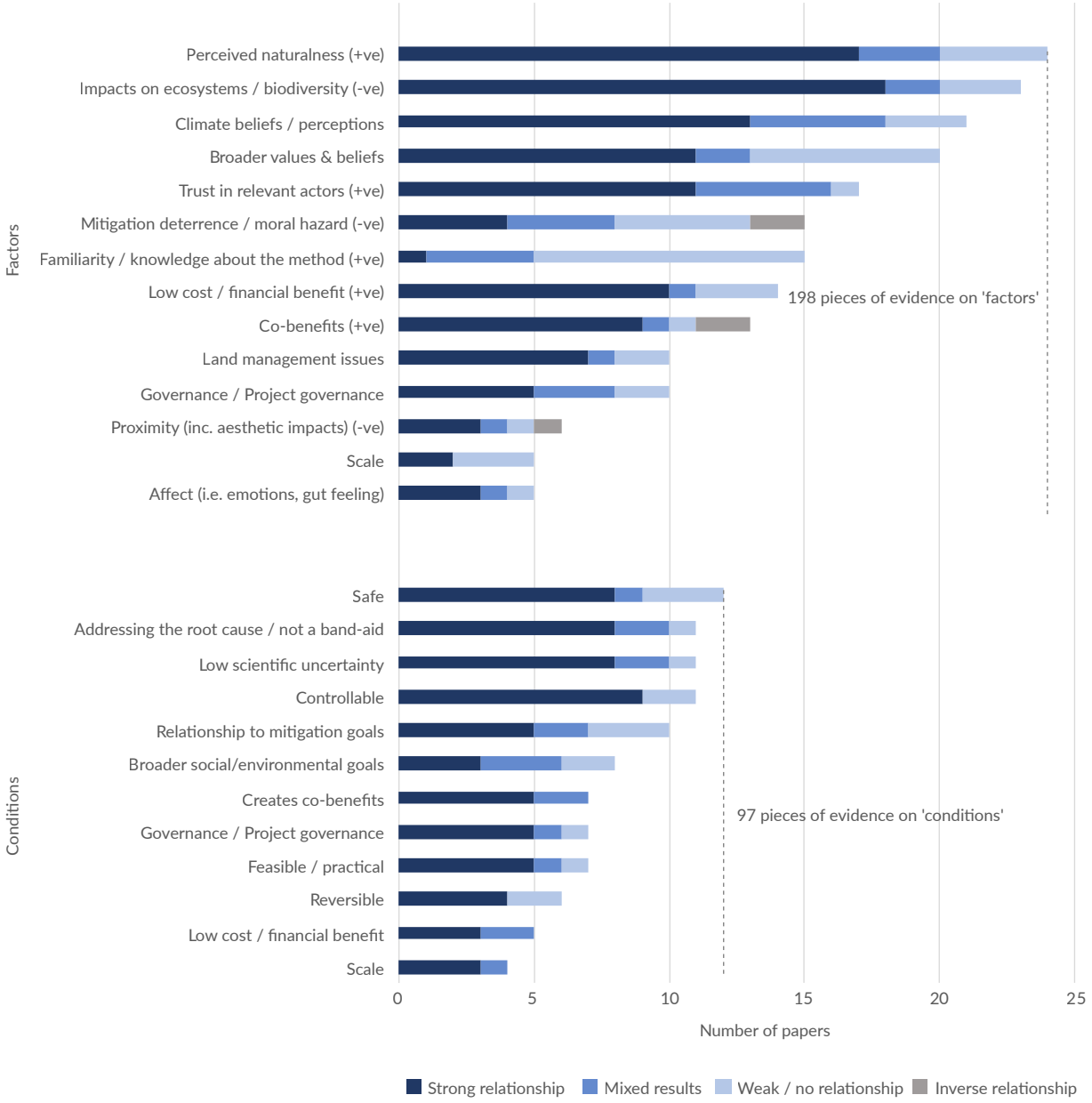


Figure 6.2 *Fourteen factors shown to drive public attitudes towards carbon dioxide removal (CDR; top) and 12 identified conditions for the deployment of CDR (bottom), from the English-language peer-reviewed literature on public perceptions (56 papers). Papers were scored according to whether they provide empirical evidence for a strong relationship between the factor or condition and public attitudes, or mixed results, or a weak relationship/no relationship, or an inverse relationship (see Box 6.2). Where appropriate, the direction of the relationship is labelled +ve (positive) or -ve (negative). Pieces of evidence = total number of papers discussing the listed factors or conditions (most papers cover more than one topic).*

The majority of papers find that these factors have a strong influence on public attitudes: CDR methods that are framed as or perceived to be more natural are more likely to be supported, and methods that have perceived detrimental impacts on ecosystems or biodiversity are more likely to be perceived negatively. Other factors often studied in the literature are values and beliefs (e.g. social identities, cultural worldviews, political affiliation), climate beliefs (e.g. belief in the urgency of climate change), and trust. For these factors, slightly more papers show mixed results or a weak relationship with public attitudes.

A large number of papers have examined moral hazard effects: the idea that CDR might

negatively impact emission reduction efforts or intentions. However, the literature does not agree on whether this factor consistently drives public attitudes. Many papers provide weak or no evidence in favour of the moral hazard hypothesis, and two provide evidence for the inverse effect – in other words, learning about or deliberating CDR might in fact increase support for emission reductions.[268,269] Similarly, there is low confidence on the extent to which people's knowledge of CDR or their familiarity with the topic influences their attitudes towards it. Finally, very few papers examine affect (i.e. subjective feelings, emotions) and scale (related to the type and site of activity, as well as the deployment footprint). This report also finds low confidence in people's proximity to proposed projects or developments being a factor that drives attitudes.

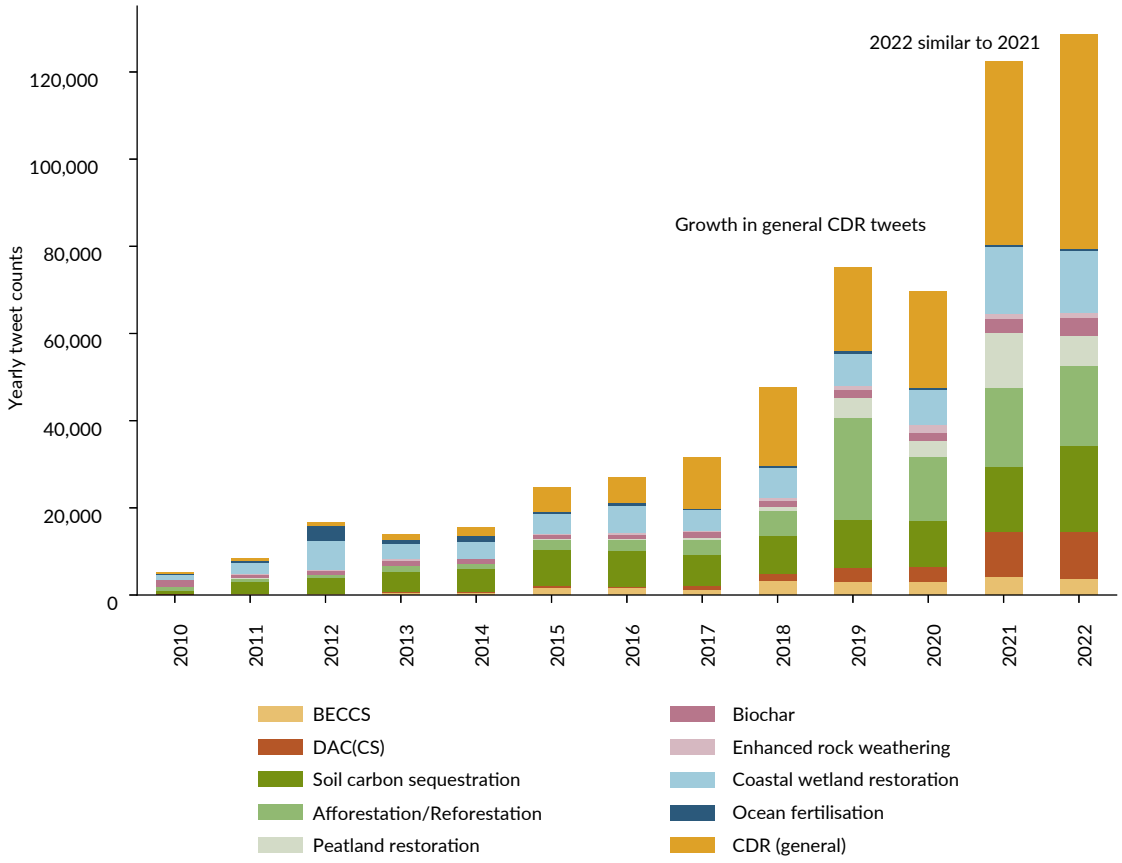
Conditions for deployment are requirements that study participants highlight as important for supporting or accepting the deployment of CDR methods. They can help develop a more nuanced understanding of how and why particular projects or proposals might become acceptable and serve as a basis for public engagement for the improvement and implementation of projects. However, fewer papers examine such conditions than look at the factors driving attitudes. The largest number of papers shows that the public wants CDR methods to be controllable, to be safe (particularly for methods involving deep geological storage), to have low scientific uncertainty, and to address the root cause of the problem. There are fewer papers on cost and profit and on co-benefits; such papers are mainly on conditions for landowner uptake of specific land-based methods.

CDR on Twitter/X

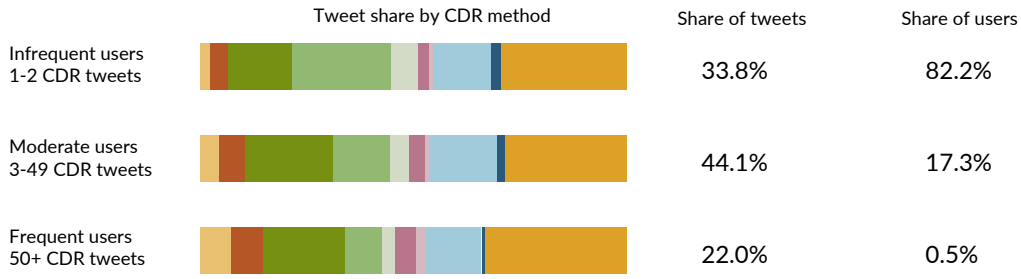
In contrast to the elicited approaches discussed in the scientific literature, social media data (i.e. non-elicited information) can be used to assess how people communicate about CDR (see Boxes 6.1 and 6.3). Twitter – now rebranded as X – is a social media platform used by many for engaging in policy-related public debates. The State of Carbon Dioxide Removal 1st edition found that English-language communication about CDR on Twitter/X grew very rapidly between 2010 and 2021,[270] with brief recessions in 2013 and 2020. This edition updates the first edition analysis by extending the data to the end of 2022 and investigating what kinds of user are posting about CDR.

In the corpus of tweets analysed, the focus on different CDR methods changed gradually over the last 12 years (see Figure 6.3a). Earlier tweets mainly focused on specific CDR methods, such as soil carbon sequestration, coastal wetland restoration, ocean fertilization, afforestation and biochar. Recent years have seen an increase in the share of tweets about CDR in general, as well as an expansion to novel CDR methods such as DACCS and BECCS. Nevertheless, the bulk share of English-language tweets is still on soil carbon sequestration, coastal wetland restoration and afforestation. Twitter/X users tend to communicate more frequently about CDR methods that are more widely known: for example, afforestation is one of the most frequently mentioned CDR methods on Twitter/X and is also the most widely known CDR method according to public awareness surveys. Additional data for 2022 show little change from 2021 in attention to CDR, in terms of both absolute numbers and the relative share of different methods. General CDR and soil carbon sequestration saw an increase of a few percentage points in their shares, whereas the relative shares for peatland restoration and for coastal wetland restoration decreased slightly. But the shares of all other CDR methods remained within one percentage point of their value in 2021.

a) Growing attention to CDR on Twitter



b) Slight differences between user groups by number of CDR tweets



c) Users from different locations and of various types

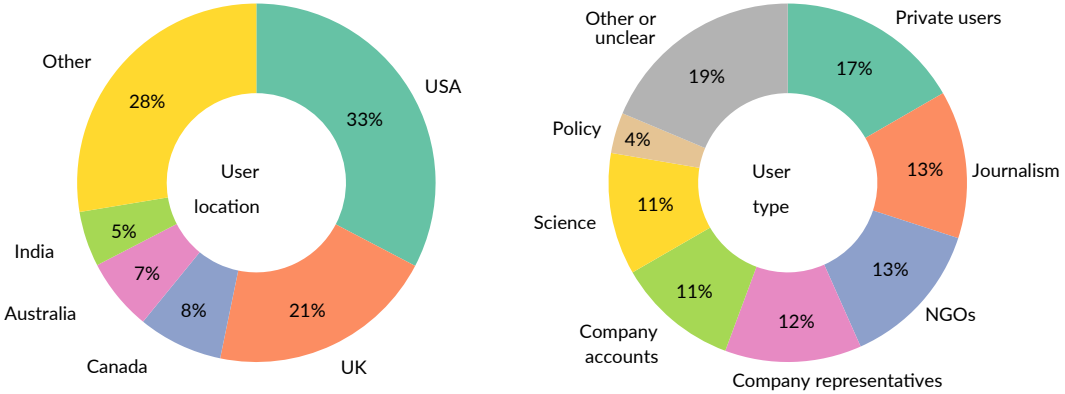


Figure 6.3 *Activity on Twitter/X related to carbon dioxide removal (CDR) by method and time, user groups by tweet frequency, share of user locations and user types: (a) Number of tweets per year and set of CDR keywords. Ocean alkalinity enhancement only resulted in very few tweets and is not reported here; BECCS = bioenergy with carbon capture and storage; DAC(CS) = direct air capture (with or without carbon storage) (b) How often users posted about CDR between 2010 and 2022 and the related shares in CDR methods, tweets and users; (c) The share of users attributable to a specific country through their self-described location (left, n = 94,096) and the shares of user types in a manually annotated sample of users (right, n = 300).*

The analysis of sentiments (i.e. whether tweets use positive, negative or neutral language) shows that across all CDR tweets positive sentiments increase over time. Tweets on biological capture methods have a positive sentiment much more often than a negative sentiment, aligning with the survey literature on perceptions.[250,251,271] Extending the analysis of tweets to 2022 reveals only small differences compared with 2021: BECCS and ocean fertilization were on average discussed more positively than before, and peatland and wetland restoration featured more prominently among both positive and negative tweets.

The above findings are robust to different subgroups of users that tweet with different frequencies about CDR (see Figure 6b and Box 6.3). There are only small deviations between subgroups: Users posting frequently about CDR post relatively more about novel CDR methods (e.g. DACCS, enhanced rock weathering, biochar, BECCS), whereas users posting only once or twice about CDR tend to post more on well-known methods such as afforestation or peatland and wetland restoration. Users posting frequently about CDR also communicate slightly more neutrally about CDR than other users. However, the general trends in attention given to CDR and sentiment towards CDR described above are valid for all subgroups with different tweet frequencies.

Different types of user are actively posting on CDR: private accounts, accounts of firms, and professionals from different fields such as business, journalism, NGOs and science (see Figure 6.3c, right). Seventeen percent of the coded users did not mention any professional activities in their self-description. The majority of accounts (60%) belong to journalists, representatives of NGOs and businesses, official company communication teams, and practitioners related to science and education, all with very similar proportions of the total. Politicians and policymakers make up only a very small percentage of users posting about CDR.

Using the self-reported location in a user's profile enabled approximately half the users in the data set to be mapped to a specific country. As only English keywords were searched to compile the data set, the strong concentration in English-speaking countries is not surprising: 70% of posts from users with an identifiable location come from Australia, Canada, the UK or the US (Figure 6.3c, left). But there are also many tweets from users located in countries such as Belgium, Chile, France, Germany, Ghana, India, Norway and Switzerland, all with shares between 5% and 1%. There are differences between countries with respect to how often users tweet about specific CDR methods and the sentiments associated with these methods. For example, users from Australia, India and the US post more about soil carbon sequestration than others. UK users post more about peatland restoration and coastal wetland restoration, while Ghanian users focus on biochar and general CDR. Across CDR methods, sentiments tend to be more negative in Australia, Canada and Germany than in India, the UK and the US.

Box 6.3 Methods: Evaluating communication about CDR on Twitter/X and in news media

CDR on Twitter/X. This analysis is based on a data set of 570,000 tweets that contain keywords specific to CDR methods or other generic CDR terms and that were posted on Twitter/X between 2010 and 2022. Only English-language tweets were included; retweets were not included. Further details on the methodology are provided in Müller-Hansen et al., 2023, and Repke et al., 2024.[270,272] The analysis used machine learning to automatically classify sentiments (i.e. the tone of the language used in tweets) as positive, negative or neutral. This classification can differ from the attitude towards CDR expressed in a tweet, as sentiment only refers to how something is said and not the position taken in the text with respect to CDR. This approach draws on well-established sentiment detection algorithms, but nevertheless has limitations; for example, algorithms sometimes struggle to detect irony. This edition of the report extends the analysis by looking more closely at the users in the data set in three ways. First, users were grouped according to how many tweets they posted on CDR topics over the entire period of the data set: those who have posted many (50+) tweets about CDR, those who have posted a moderate number (3–49), or those who have posted just one to two tweets. Second, the types of profile associated with the tweets was manually annotated by coding a sample of 300 users: 100 representative users from each of the groups identified in step 1. These annotations were used to derive estimates about the composition of the users in the data set. Third, users were assigned to different countries based on the information they provide in the "location" field of their profile using a geolocation extraction algorithm evaluated for Twitter/X.[273]

CDR in news media. For this analysis, a keyword-based search query was entered in the LexisNexis Newspapers and Wires database for nine CDR methods to identify news media articles on CDR. The search was global in coverage but restricted to English-language articles appearing both in print and online. The results were filtered to a list of 122 newspapers compiled from (1) the list of Media and Climate Change Observatory core sources[274] (a prominent compilation of sources for media studies on climate topics) and (2) a list of general interest newspapers (i.e. not specialist journals) that yielded more than 1,000 results for the CDR keywords. To eliminate false hits, a protocol for inclusion/exclusion was developed and approximately 1,500 articles were manually coded. A pre-trained classifier developed for identifying CDR methods in scientific articles was then applied[275] to predict the relevance of subsequent articles in the data set. Automatically classified articles had high precision compared to the manually coded set, but relatively low recall. As such, the initial results represent a lower bound of news media discussions on CDR. An exception to this concerns *CDR (general)*, which, as in the Twitter analysis, is a category included to capture broader discussions on CDR concepts and their role in climate policy, as opposed to specific discussions of individual CDR methods. This general category showed both low agreement between different manual coders and poor matching between the manually and automatically coded sets. This is likely due to the subjective boundary in these articles between what should be considered a discussion

that "primarily" focuses on CDR (which is included in the coding scheme) versus a discussion that only "tangentially" focuses on CDR (which is excluded in the coding scheme). This report therefore does not present results for the CDR (general) category in the main figures but discusses the implications of expanding the analysis to this category. In addition, it should be acknowledged that the coverage of LexisNexis is likely incomplete and only partially overlaps with other databases such as NewsBank, ProQuest or Factavia.[276]

CDR in news media

The mass media ecosystem – newspapers, television, radio broadcasting and online news platforms – is a key source of scientific information for the general public.[277] It can influence perceptions by shaping how much coverage different topics receive and by propagating values, worldviews and opinions on a range of issues.[278–280] This section focuses on the reporting of CDR in English-language news media articles over the past three decades (1990–2021).

Much research has investigated news media portrayals of climate change, including climate denial discourses and "false balance" in reporting on the issue.[281] Similarly, studies have looked at media portrayals of emerging technologies, such as genetically modified organisms and cultured meat.[282,283] However, only a few studies have focused on reporting of CDR. The majority of these studies investigate the overarching categories of geoengineering or climate engineering, where CDR is not the main focus.[284–289] A handful of studies have dealt with CDR methods themselves or their prerequisites, covering carbon capture and storage,[290–292] BECCS[293,294] and coastal wetland restoration.[295] Given the nuances associated with CDR, including complexities such as the meaning of *net zero* and concerns that CDR could reduce incentives for emission reductions, it is surprising that few scientific studies have examined how these methods have been communicated to the general public.

This section provides a new analysis of how English-language newspapers portray specific CDR methods. Approximately 9,100 articles that discuss CDR methods were found, with the main period of media reporting starting in 2007 (see Figure 6.4).[2] A major increase in coverage occurred in 2019, peaking during October and November 2021 when a wave of countries updated their climate targets prior to COP26. Since many of these targets included net zero pledges, the resulting climate policy discourse tended to feature CDR prominently. Prior to 2019, peaks in reporting on CDR also centred on similar international events, including COP15 in Copenhagen in 2009; COP13 in Bali in 2007, where several international forestry initiatives were announced; and COP6 in The Hague in 2000, where the role of forests as carbon sinks first sparked significant debate under the UNFCCC process.

2 *If the "CDR (general)" category were included, as it is in the Twitter analysis, the yielded articles would approximately double to around 18,000. However, as discussed in Box 6.3, they are excluded due to low confidence.*

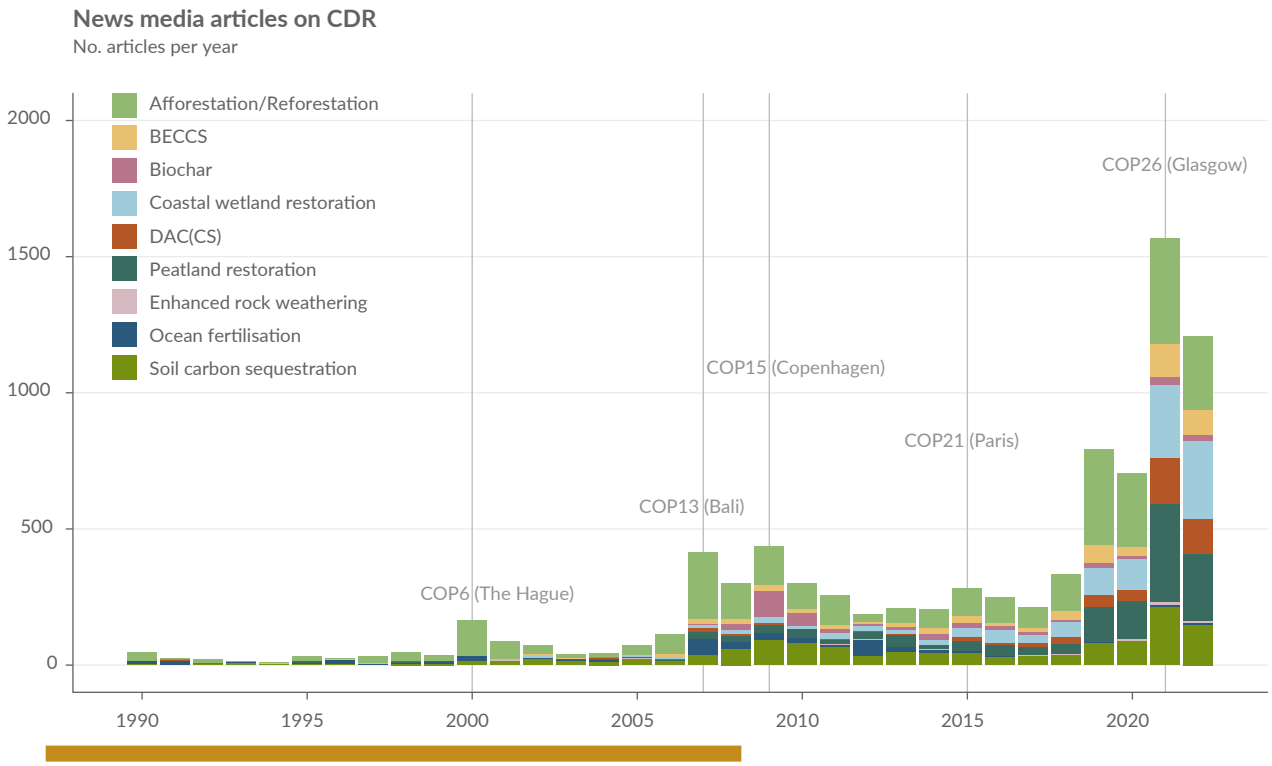
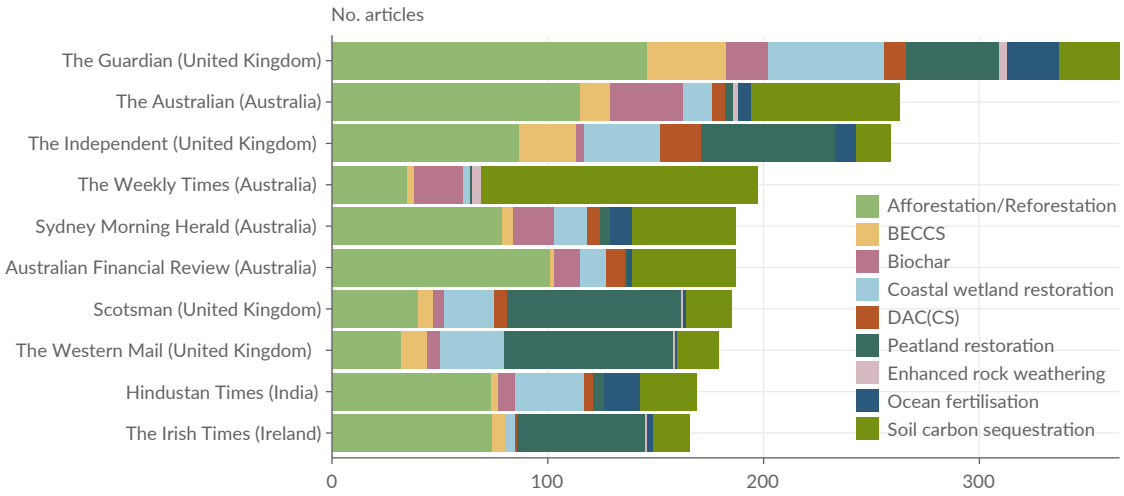


Figure 6.4 *News media articles on carbon dioxide removal (CDR) methods. Articles are double counted where they feature more than one CDR method. "CDR (general)" is excluded due to low confidence. Keyword searches for ocean alkalinity enhancement did not find any relevant articles. BECCS = bioenergy with carbon capture and storage; DAC(CS) = direct air capture (with or without carbon storage).*

Mentions of CDR in the data set are relatively concentrated in specific news media and countries. The Australian and UK press dominate coverage in this sample, accounting for eight of the top ten sources by total articles (see Figure 6.5, top panel). Soil carbon sequestration accounts for a larger share of articles than average in Australia, reflecting its higher state of integration into Australian climate policy.[244] Ecosystem restoration discourses (e.g. peatland restoration and "rewilding") are more prominent in the Irish and UK press (see Figure 6.5, bottom panel), while afforestation and coastal wetland restoration have larger shares in India and Pakistan (although this analysis only covers the English-language press in those countries).

News media articles by CDR technology and source, 1990–2021



Share of news media articles by CDR technology and source country, 1990–2021

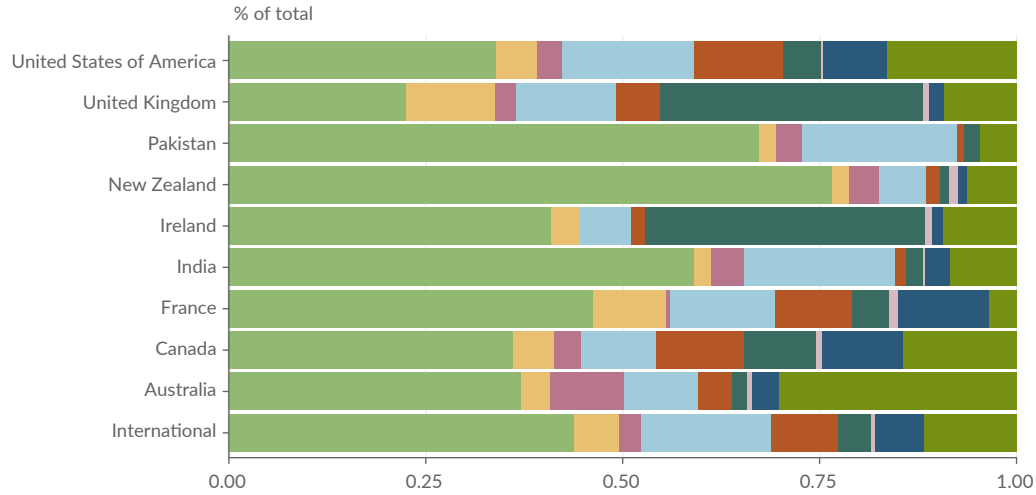


Figure 6.5 *News media articles on carbon dioxide removal (CDR) by source and location. The ten sources (top) and locations (bottom) with the highest number of hits are displayed in order. Articles are double counted where they feature more than one CDR method. The results are for English-language articles only and may not be representative of complete national media conversations on CDR. BECCS = bioenergy with carbon capture and storage; DAC(CS) = direct air capture (with or without carbon storage).*

A random sample of around 1,500 news media articles, which were read and manually coded, indicated that discussions of CDR methods tend to intersect with other concepts and mitigation approaches, including (fossil-based) carbon capture and storage, carbon capture and utilization (e.g. synthetic fuel production, biofuels), and avoided emissions (e.g. forest carbon offsets). Journalists do not necessarily distinguish between these different categories of mitigation, yet it is important to communicate the specific role of CDR as distinct from emission reduction efforts (see Chapter 1 – Introduction).

Box 6.4 Limitations and knowledge gaps

This report has identified areas on which future assessments can build, including:

- Data on awareness and familiarity are still sparse and difficult to compare across studies. Very few general public questionnaires test the same measures at different time points.[301] Meanwhile, CDR expert studies are very heterogeneous and specific, and thus difficult to extrapolate to other contexts. More longitudinal research is needed to track the development of these important indicators over time.
- Future work could consider how findings and methodologies differ depending on the type of actor in question, because the small evidence base makes it difficult to draw general conclusions at present. More research is also needed on conditions for deployment, which allow public groups and adopters to positively engage with CDR.
- The scientific evidence base on CDR perceptions is still patchy in geographical terms. There are few studies, and very few lead authors, from Africa, South/Central America or Pacific countries other than Australia and New Zealand. The potential for many CDR methods is high in these regions; therefore, more knowledge about CDR perceptions in these populations is needed.
- All sections of this chapter are based on English-language data, which was noted as a limitation in *The State of Carbon Dioxide Removal* 1st edition. A more balanced assessment would include non-English sources, but this would require a large international team and dedicated funding, since local input will be essential to avoid missing vital social and cultural nuances.
- Non-elicited data from social and news media are used to provide indicators that are consistent over time. However, the restructuring of the Twitter/X platform in late 2022 must now be considered, as this saw an exodus of environmental communicators302 and a shift in the way the platform is used, creating obstacles to its future use as a consistent indicator.
- The data presented in this report suggest that there are similarities between the familiarity found in surveys and attention to CDR methods on Twitter/X. Future research should investigate the relationship between indicators derived from social media and surveys.
- Two cross-cutting knowledge gaps could be addressed in future research. First, the policy context is evolving rapidly (see Chapter 5 – Policymaking and governance), particularly with net zero targets, which are shown to greatly influence news media output. There is a need for more research linking the policy context to public perceptions in a way that views policy and public attitudes as mutually influencing and reinforcing one another rather than existing in isolation. Second, monitoring, reporting and verification is emerging as a topic of critical importance to the future of CDR (see Chapter 10 – Monitoring, reporting and verification), and it could be beneficial to link public perceptions work with this field, for instance in determining whether transparent and publicly accessible monitoring, reporting and verification processes could help build trust for CDR deployment.[303]

Strong variations were observed in the amount of critical reflection that CDR methods receive. For instance, a series of articles on DACCS plants tended not to offer a cautious appraisal of these methods, in contrast to broader and more critical pieces that introduce CDR as an overarching concept. One series of opinion articles in the Australian press frequently referred to soil carbon sequestration and biochar as methods that could advance national climate policy in place of emission reduction efforts. Other articles in the Australian press emphasized the low-carbon credentials of the cattle ranching sector, based on claims that livestock stimulate soil carbon sequestration, which has been challenged in the literature when one considers the overall climate impact of livestock.[296] These discourses no doubt dovetailed with broader contestations over climate policy in Australia, in which soil carbon sequestration was promoted by the Liberal party as a component of a policy direction comprising "technology not taxes".[297,298] These examples highlight the risk that interest groups could leverage CDR to propagate discourses downplaying the need for ambitious climate policy and action, potentially continuing a longer tradition of climate obstruction through the mass media.[299,300] However, given the extremely limited literature on this subject, and the early stage of this analysis, it remains important to further assess the degree to which CDR discourses are exploited in the media.

6.3 Outlook

Active engagement with the general public and with interested parties is both an opportunity and a challenge for CDR. The literature on public perceptions is beginning to yield lessons for responsible communication of CDR.

Active engagement with interested parties, including the general public, presents a considerable opportunity for mutual learning. Public groups are an essential source of knowledge for developing more effective and responsible CDR policies and methods. However, communication challenges arise due to low prior awareness about CDR and the risk of spillover effects from controversies in related sectors.[304] The purpose of communicating about CDR is not to minimize opposition – or to maximize approval – but to facilitate mutual learning and informed participation in decision-making. Given persistent low levels of awareness about CDR, and the challenge of upscaling CDR to the level required to meet the Paris temperature goal (Chapter 8 – Paris-consistent CDR scenarios), developing responsible approaches for communication and engagement with the wider public and potential adopters needs to become a priority.[305]

The following seven lessons for responsible communication are derived from explicit recommendations in the perceptions literature during the time period covered by the review (noting of course that these are all English-language studies, with a distinct geographical skew):

Be careful with terminology. Pre-existing technical terms that are distinct from CDR (e.g. "carbon capture") can confuse.[306] The term "negative" emissions can elicit unduly negative responses.[307] "Geoengineering" can spark negative sentiments.[270] Different ways of framing communication are likely to generate different public responses.[264]

Talk about CDR in context. Crucial contextual factors include the policy context,[308] different

components of CDR systems,[309] the scale of CDR required domestically,[265] and the wider context of climate change mitigation and adaptation.[256,310] Communications need to be tailored to specific CDR methods and locations.[243]

Give – and receive – information about CDR. Giving information about CDR will increase awareness,[301] and providing information on scientific consensus can neutralize conspiracy theory effects in sceptical audiences.[311] Continual engagement to obtain feedback and assess public reservations is needed to progress research and development.[312]

Talk about (co-)benefits. Perceptions of benefits are a strong driver of acceptance.[249,267,313] Particularly relevant benefits may relate to long-term sustainability, environmental friendliness, controllability, cost-effectiveness and energy provision.[314,315]

Also talk about negative attributes. By identifying and deliberating negative attributes, innovation trajectories could be altered to avoid or minimize them. Salient aspects that could affect future well-being[316] include displeasing aesthetics, quick fixes, artificiality, risks and unknown effects,[301,314,317] as well as threats to emotionally and ethically significant ecological and geological systems.[315]

Do not weaken support for emission reductions. CDR should be seen as only a small part of larger efforts to tackle climate change.[256,262] Responsible communication strategies should emphasize the severity of failing to reduce emissions and should avoid framing CDR as a backup strategy or temporary "plan B" while working on more-sustainable solutions to climate change.[318,319]

Avoid framing CDR as natural (or otherwise). Perceived "naturalness" is known to increase acceptance of CDR,[320] whereas perceived "tampering with nature" is known to lower acceptance.[248] However, where the lines are drawn on what constitutes a "natural" or "unnatural" method is arbitrary and diverts attention away from the actual qualities of CDR methods.[268]

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