ASMASYS

ASMASYS – Assessment framework for marine CO_2 removal and synthesis of current knowledge

New framework for the uniform and knowledge-based assessment of marine CO_2 removal methods

CDRmare INSIGHTS

In the CDRmare research consortium ASMASYS, experts from the natural sciences, social sciences and humanities have developed an extensive assessment framework for ocean-based carbon dioxide (CO_2) removal methods and projects. By applying this framework, responsible actors can systematically gather and compile all necessary information to make an evidence-based decision on the potential implementation of marine CO_2 removal methods.

1 Society will need to address not only the development, but also the implementation of concrete strategies and projects for targeted marine CO_2 removal. The way we discuss these issues and the knowledge on which we base our decisions are essential aspects. The new ASMASYS assessment framework aims to make the debate more objective and to provide a basis for informed decision-making.

2 Which ocean-based methods Germany should apply to achieve the required scale of CO_2 removal depends not only on whether a given method is feasible, but also on whether its use and the associated impacts on humans and the environment are desirable.

3 In order to comprehensively evaluate a given CO_2 removal method or project with the aid of the assessment framework, information from various fields of research, and from practice, is called for. However, weighing the information gathered regarding the feasibility, benefits and risks to make a sound choice remains the responsibility of political decision-makers.

4 The assessment framework developed by the ASMASYS research consortium has successfully passed all test runs so far. Its question-based format is a particular strength, as it gives different actors the opportunity to participate in the assessment process, allowing all those involved to learn from each other and to transcend the borders between disciplines and areas of responsibility.

5 In order to comprehensively analyse a given CO_2 removal project, initiators of the assessment process should follow six basic rules.

6 Questions that currently remain unanswered do not prevent an assessment. Rather, they show in which directions more intensive research is needed, or where we as a society must weigh the risk associated with the use of ocean-based CO_2 removal methods and, in some cases, knowingly accept them.

CDRmare
DAM German Marine Research Alliance
SPONSORED BY THE
Federal Ministry of Education and Research
Freie Hansestadt Bremen
Hamburg Behörde für Wissenschaft, Forschung, Gleichstellung und Bezirke
MV Mecklenburg-Vorpommern
Niedersächsisches Ministerium für Wissenschaft und Kultur
SH Schleswig-Holstein Ministerium für Bildung, Wissenschaft und Kultur

Key message 1

Society will need to address not only the development, but also the implementation of concrete strategies and projects for targeted marine CO_2 removal. The way we discuss these issues and the knowledge on which we base our decisions are essential aspects. The new ASMASYS assessment framework aims to make the debate more objective and to provide a basis for informed decision-making.

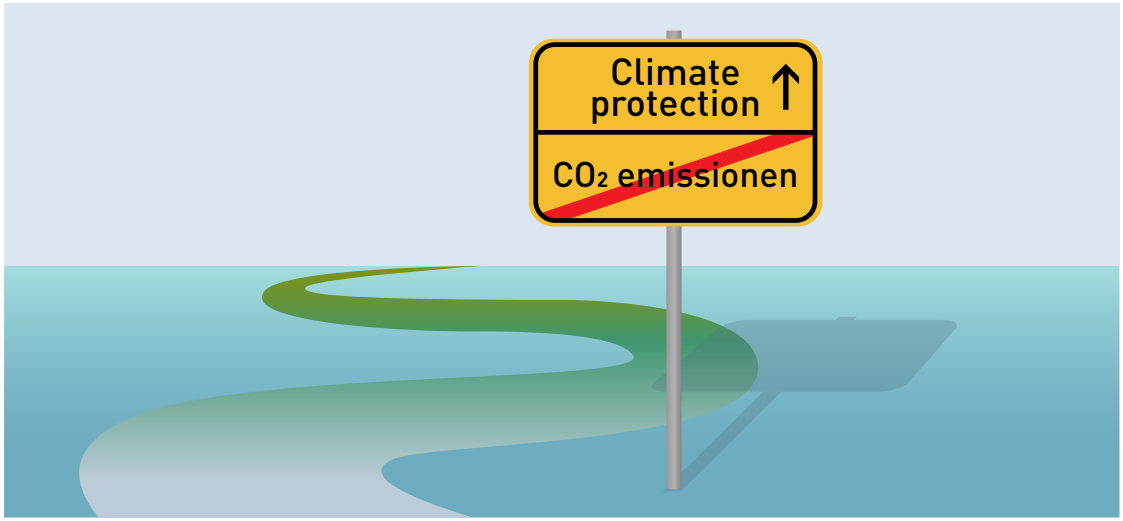
Based on the numbers, there is no real alternative: if Germany wants to achieve its climate target of greenhouse gas neutrality by 2045, it will have to deliberately remove carbon dioxide (CO_2) from the atmosphere even if it succeeds in completely eliminating all avoidable greenhouse gas emissions within the next 20 years. The reason for this is hard-to-avoid and unavoidable residual emissions, which must be compensated for using targeted CO_2 removal.

In this regard, potential removal methods include various land-based options and those that amplify the ocean's natural CO_2 uptake. Each method has its share of benefits and risks. Certain methods are »tried and true« and have, in some cases, been applied for centuries (e.g. soil-conserving farming methods); others apply such cutting-edge technologies that it remains uncertain whether or not they could be deployed on the scale that is required.

Nevertheless, policymakers and industry need to pave the way for the future use of CO_2 removal methods now. To do so, they will need information that is as sound and comprehensive as possible to assess individual methods or projects. These assessments should be based on a structured process that integrates various forms of expertise, allows methods and projects to be compared, and bears the overarching goal of achieving climate-resilient and sustainable development in mind.

It is precisely here that the new assessment framework for ocean-based CO_2 removal methods and projects, developed by CDRmare experts over the past three years in the collaborative project ASMASYS, comes into play. The framework helps responsible decision-makers to ask the right questions for their assessment. It is intended to make the discussion regarding the potential application of ocean-based CO_2 removal methods more structured and objective. In this regard, the outcomes of individual assessment processes remain open: the information gathered may argue both for and against applying a given CO_2 removal method.

The intended CO_2 removal only concerns the currently unavoidable residual emissions. These emissions primarily stem from agriculture, cement production, and waste incineration, and will likely be more substantial than many assume – another reason why all parties involved must realise that the theoretical option of CO_2 removal using ocean-based methods should never undermine efforts to put an end to avoidable greenhouse-gas emissions once and for all.



Graphic: Rita Erven, CDRmare

Key message 2

Which ocean-based methods Germany should apply to achieve the required scale of CO_2 removal depends not only on whether a given method is feasible, but also on whether its use and the associated impacts on humans and the environment are desirable.

Or to put it another way: is applying the respective CO_2 removal method actually a good idea? Not everything that is feasible is desirable, and vice versa. The same applies to ocean-based CO_2 removal methods. Based on the current state of knowledge, each of the currently known CO_2 removal and storage methods would entail substantial advantages and disadvantages if they were deployed on a large scale.

Accordingly, the major challenge while developing the new ASAMSYS assessment framework for ocean-based CO_2 removal methods was to clearly differentiate between the technological, political and legal feasibility of a given method, and at the same time to ask how desirable its potential impacts would be in view of the global development goals. The framework equips researchers, practitioners and decision-makers to comprehensively evaluate marine CO_2 removal methods and projects. To do so, the framework uses structured key questions that clearly distinguish between the two spheres »feasibility« and »societal desirability« while also covering all key assessment criteria.

In this way, the researchers have ensured that, in future assessment processes, the potential risks and benefits of targeted CO_2 removal are evaluated not just from technological and administrative standpoints, but also on the basis of values. This includes assessing which CO_2 removal methods are ultimately compatible with our societal norms and values, whether their benefits and risks can be reconciled with widely accepted concepts of justice, and whether employing them would help to achieve widely accepted global goals (e.g. the UN's Sustainable Development Goals). There are certainly differing views on all three aspects, but the framework makes it possible for all parties involved to engage in a transparent and knowledge-based debate on them.

Key message 3

In order to comprehensively evaluate a given CO_2 removal method or project with the aid of the assessment framework, information from various fields of research, and from practice, is called for. However, weighing the information gathered regarding the feasibility, benefits and risks to make a sound choice remains the responsibility of political decision-makers.

For each project or method to be assessed, the new framework addresses seven thematic areas. Accordingly, a wide range of experts must come together to provide the requisite information for the assessment process. This includes experts from the fields of engineering, the climate sciences, law, social sciences, economics, marine biology and other natural sciences, and environmental ethics. In addition, public administration experts and representatives of various interest groups are needed. As such, evaluating a given CO_2 removal method or project is always a joint effort and should never be done by an individual.

The assessment process seeks answers to the following seven key questions:

1. Is deploying the CO_2 removal method in question feasible from both a technological and ecological standpoint? *(technological-ecological feasibility)*
2. Does the method receive sufficient support from political decision-makers and the public? *(political feasibility)*

3. Do regional, national and international legislation and agreements allow the deployment of the CO_2 removal method? *(legal feasibility)*
4. To what extent can deploying the method mitigate climate change? *(climate efficacy)*
5. What would it cost to implement the method and what additional economic benefits, if any, would it bring? *(economic efficiency)*
6. If the method were deployed, would the resulting burdens and benefits be distributed equitably, and would the corresponding regulations be just? *(justice aspects)*
7. What consequences would the deployment of the method have for the environment beyond the effects on humans and how should these be assessed? *(environmental ethics aspects)*

For each key question, there are several key criteria and more detailed sub-questions. These are used to address all indicators needed to ultimately decide whether or not e.g. a project would enjoy sufficient support from the public and political decision-makers.

As such, the assessment framework offers a tool enabling actors to systematically find answers to all important questions that need to be addressed prior to deploying a given ocean-based CO_2 removal method. They support the structured gathering of practically applicable knowledge. However, evaluating the resulting information, weighing the facts, and making the final decision as to whether or not a specific CO_2 removal project or method should be pursued, remains the responsibility of political decision-makers.

That being said, the CDRmare experts assume that, for every ocean-based CO_2 removal method, there can be circumstances under which the planning must be discontinued. Over the next three years, the researchers will investigate which circumstances fall into this category.

Key message 4

The assessment framework developed by the ASMASYS research consortium has successfully passed all test runs so far. Its question-based format is a particular strength, as it gives different actors the opportunity to participate in the assessment process, allowing all those involved to learn from each other and to transcend the borders between disciplines and areas of responsibility.

To test the assessment framework, researchers from the ASMASYS consortium hosted four workshops with representatives from academia, various ministries and government agencies, and environmental organisations. For each workshop, the experts prepared a fictional but plausible application for a selected CO_2 removal method. The workshop participants were tasked with addressing the seven key questions and gathering all the information needed to make a knowledge-based decision.

To do so, the participants attempted to collectively find answers to 96 detailed questions, which led to intensive and comprehensive exchanges. In the process, the individual participants not only learned from their fellow experts; the dialogue format also allowed them to jointly gain new insights and a grasp of the disparate standpoints on ocean-based CO_2 removal methods and projects. By the end of each workshop, the participants had arrived at a shared view on how feasible or desirable the proposed (fictional) CO_2 removal project was and how they had jointly arrived at this conclusion.

This illustration provides an overview of the topics and assessment criteria provided by the new assessment framework for evaluating marine CO_2 removal methods. There is a clear distinction between the feasibility of a given method and its potential desirability. An important note: each of the indicators shown here can be relevant for more than one assessment criterion. In this way, the assessment guidelines successfully transcend the borders between disciplines. Further, the circular format conveys the equality of the respective aspects; no single aspect is more important than its counterparts.

Graphic: Rita Erven, CDRmare, based on a template from the ASMASYS team

The basic approach of arriving at information on key parameters by asking questions proved to be extremely beneficial. It helped the workshop participants to understand which specific information was needed. For example: when it came to the aspect of water quality and enhanced alkalinity, the researchers did not satisfy themselves with the parameter »water quality« and instead made the formulation more precise. At the end, one question was: »What impact does the introduction of the proposed substance for alkalinity enhancement have on the lives of marine organisms?

As fictional sample applications, the experts used a small-scale project on enhancing alkalinity in German coastal waters, a project to establish macroalgae (kelp) forests off the North Sea island Sylt, one for storing CO_2 in the oceanic basalt crust off the coast of Norway, and plans to sequester captured CO_2 in sandstone formations beneath the German North Sea. A brief summary of the information gathered can be found in the official ASMASYS Interim Synthesis Report, which can be downloaded from the CDRmare website; see the section Info materials / More CDRmare materials (https://cdrmare.de/en/morematerials/)

Key message 5

In order to comprehensively analyse a given CO_2 removal project, initiators of the assessment process should follow six basic rules.

Adhering to these rules paves the way for a successful assessment process and the optimal quality of the information gathered. The six rules are as follows:

1. Ensure that interdisciplinary experts and practitioners with relevant expertise for all seven key questions of the framework are involved in the assessment process – especially those from the natural and social sciences, economists, environmental ethicists, engineers, as well as legal and regulatory experts from all relevant subfields.
2. As far as this is possible, make sure representatives of all (directly) affected parties are involved in the assessment process (i.e. local community members, but potentially also actors representing those who stand to benefit from the climate effects of an CO_2 removal option).
3. Clearly and transparently communicate all aspects of the planned CO_2 removal activity to those involved in the assessment process (including the sources of all materials needed, and what will happen after the conclusion of the activity)
4. Begin the assessment process with the key question that those involved in the assessment process consider to be the most critical or most problematic in connection with the proposed CO_2 removal option. Which question that is depends on the project's context. This in turn means that different assessment processes can and should begin with different aspects.
5. Work your way through the assessment framework together and one key question at a time. As you do, stay oriented on the respective detailed questions and indicators, and gather all the information needed in order to answer the questions at the »criteria« and »key questions« levels.
6. Clearly document disagreements, discussions and decision-making processes.

The extent to which the initiators of an assessment process can follow these rules largely depends on their own resources and options. Nevertheless, everyone involved should do their best to follow all six rules.

Key message 6

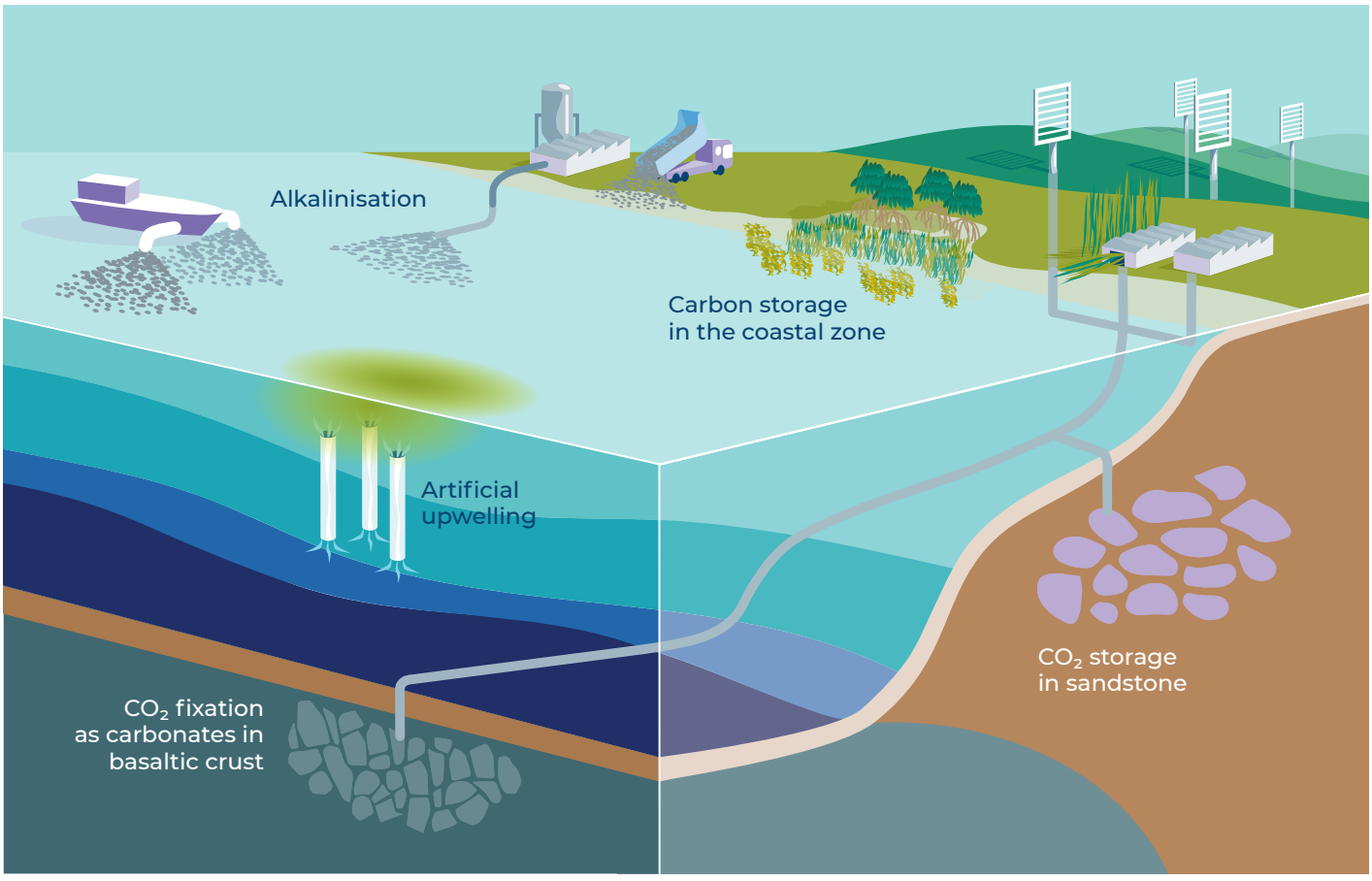
Questions that currently remain unanswered do not prevent an assessment. Rather, they show in which directions more intensive research is needed, or where we as a society must weigh the risk associated with the use of ocean-based CO_2 removal methods and, in some cases, knowingly accept them.

Answers are lacking, for example where the technological development of a given CO_2 removal method is still limited, or where it has not yet been possible to study the environmental risks – both in the immediate vicinity of the application site and in distant waters.

However, identifying such unanswered questions is extremely helpful for many participants in the process; in some cases, they can show the experts where further research is needed.

If the question at hand cannot be pursued and answered using scientific methods – which is a distinct possibility – the recognition of this fact signals to all parties involved that risks must be weighed in order to arrive at a final decision. This in turn means that all available knowledge regarding the potential risks and benefits of the proposed CO_2 removal project must be systematically gathered and documented in detail – ideally with the assistance of specialists from the scientific community.

At this point, the experts should also have the opportunity to submit their recommendations. Conceivable options are, for example, initially testing a given CO_2 removal method or implementing a corresponding project on a small scale, in light of the previously identified unanswered questions. In this context, specialists with the requisite experience could serve as consultants and assess the outcomes before any implementation on a larger scale were (potentially) planned.



The CO_2 removal and storage methods explored in the CDRmare research mission.
Graphic: Rita Erven, CDRmare

Link to the synthesis report

You can find further information on the CDRmare assessment framework for marine CO_2 removal methods in the ASMASYS synthesis report »Unified assessment framework for proposed methods of marine CDR and interim knowledge synthesis«, which you can download here.

IMPRESSUM

Text: Sina Löschke, Matthias Kreuzburg, Gregor Rehder, Miranda Boettcher, Lukas Tank, Christian Baatz and the ASMASYS consortium // Editorial and contact: Sina Löschke (sloeschke@cdrmare.de) // Design: Rita Erven
GEOMAR Helmholtz Centre for Ocean Research Kiel // Wischhofstr. 1 – 3 // 24148 Kiel & Leibniz Institute for Baltic Sea Research, Warnemünde (IOW) // Seestraße 15 // 18119 Rostock
// January 2025

These CDRmare Insights are to be cited as follows:
Löschke, S., Kreuzburg, M., Rehder, G., Boettcher, M., Tank, L., Baatz, C. and the ASMASYS consortium (2025): *CDRmare Insights: New guidelines on the uniform and knowledge-based assessment of marine CO_2 removal methods*, pp. 1-8, DOI 10.3289/CDRmare.45

ASMASYS asmasys.cdrmare.de
cdrmare.bsky.social
linkedin.com/company/cdrmare/
CDRmare Wissenstransfer transfer@cdrmare.de

CDRmare

ASMASYS – Assessment framework for marine CO_2 removal and synthesis of current knowledge is a research consortium within the scope of the CDRmare research mission. In the German Alliance for Marine Research (DAM) research mission CDRmare, various marine CO_2 removal and storage methods (alkalinity enhancement, blue carbon, artificial upwelling, CCS) are investigated with regard to their potential, risks and trade-offs, and consolidated using a transdisciplinary assessment framework.