SEAO2 CDR

STRATEGIES FOR THE EVALUATION & ASSESSMENT OF OCEAN BASED CARBON DIOXIDE REMOVAL

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Executive Summary

This Deliverable (D5.2) *Multi-dimensional OCDR governance framework* has been developed within the Horizon Europe project **SEAO2-CDR: *Strategies for the Evaluation and Assessment Of Ocean based Carbon Dioxide Removal*.** The SEAO2-CDR project examines the scientific, environmental, economic, societal and governance conditions associated with marine-based carbon dioxide removal (mCDR[1]), with the aim of supporting robust assessment of emerging approaches and informing their responsible governance.

mCDR is receiving increasing attention as part of the wider portfolio of approaches that may contribute to achieving climate-neutrality objectives. Carbon dioxide removal will be needed to counterbalance residual emissions in pathways towards net zero, but cannot substitute for rapid and sustained emissions reductions. At the same time, mCDR comprises a heterogeneous set of approaches that differ substantially in technological maturity, carbon-removal potential and durability, environmental effects, spatial characteristics and governance requirements. Their interaction with dynamic marine ecosystems, multiple uses of ocean space and overlapping jurisdictional regimes makes their governance particularly complex.

This deliverable builds directly on D5.1: *Legal, ethical and policy implications of OCDR*, which established the legal, ethical, political and geopolitical foundations for the governance work undertaken in Work Package 5 (WP5). D5.1 demonstrated that mCDR does not operate in a legal vacuum: existing international obligations already establish requirements concerning environmental assessment, due diligence, monitoring, transparency and international cooperation. It also showed that mCDR cannot be treated as a legally uniform category, as different technique families engage different regulatory gateways and accountability requirements. Importantly, progression towards larger-scale activity was identified as a threshold problem in which legal scrutiny, due-diligence requirements and demands on institutional capacity intensify as the scale, environmental footprint, foreseeability of harm and transboundary reach of an intervention increase.

D5.2 takes the next step by translating these findings into a scientifically grounded, stakeholder-oriented and multi-dimensional governance framework. Its objective is to move beyond the identification of individual governance gaps and provide an operational model for determining whether, and under what conditions, mCDR research, experimentation and possible progression should proceed. The central premise is that responsible mCDR governance needs to be technique-specific, stage- and scale-sensitive, adaptive and multi-level, combining common principles and safeguards with differentiated requirements appropriate to particular interventions. Governance should enable legitimate research and learning without creating a presumption of subsequent deployment, and should preserve the possibility of modifying, suspending or discontinuing activities where relevant conditions are not met.

Approach and methods

The deliverable draws on the research, evidence and analytical work generated across the SEAO2-CDR project. It integrates the legal, ethical and geopolitical findings of D5.1 with scientific and technical evidence generated through WPs 2 and 3, stakeholder and societal findings from WP4, commercial and

[1] The term "ocean-based carbon dioxide removal" (OCDR) is retained in the deliverable title in accordance with the Grant Agreement. Throughout the text, "marine carbon dioxide removal" (mCDR) is used interchangeably with OCDR.

market considerations developed in WP6, and expert and stakeholder engagement undertaken through the WP5 Communities of Practice (CPr) network. This engagement included semi-structured interviews, consultations, expert exchanges and workshop-based activities, providing practical insights into legal feasibility, permitting and authorisation, ethical and justice concerns, monitoring, reporting and verification (MRV), stakeholder inclusion and conditions for responsible piloting and possible progression.

The deliverable also reflects the project's broader approach to scientific and technical readiness. In particular, readiness is not treated simply as a question of whether a technology can technically operate. Instead, a whole-system perspective considers technological maturity together with carbon-removal performance and durability, the ability to monitor and verify outcomes, and the environmental implications of larger-scale operation.

Main findings and governance framework

The analysis aligns with recent literature and assessments in identifying fragmentation, rather than a complete absence of relevant rules or institutions, as a central governance challenge facing mCDR. Existing governance arrangements already provide important elements, including environmental authorisation, scientific assessment, monitoring, stakeholder participation, research support and marine planning, but these remain distributed across legal regimes, policy domains, institutions and stages of technological development and do not yet operate as a sufficiently coherent system for decision-making under uncertainty.

Against this background, D5.2 develops five analytically distinct but operationally interdependent dimensions:

1) Legal and regulatory arrangements, addressing legal permissibility, regulatory gateways, procedural safeguards and accountability;
2) Ethical and social acceptability, addressing justice, legitimacy, acceptability and the distribution of risks, burdens and benefits;
3) Scientific knowledge, monitoring and uncertainty, establishing the evidentiary basis for decisions and the treatment of remaining uncertainty;
4) Support instruments, economic incentives and risk-sharing mechanisms, addressing the sequencing of support, economic incentives and the distribution of financial risks; and
5) Institutional and multi-level governance, addressing the allocation of responsibilities, institutional capacity and coordination across governance levels.

None of these dimensions are treated as hierarchically prior to the others. Their separation is analytical; in practice, responsible governance depends on their coordinated application. Legal authorisation, for example, depends on adequate scientific evidence; scientific findings need to be translated into regulatory and institutional decisions; economic support should evolve in line with scientific and governance readiness; and legitimate governance requires meaningful opportunities for affected actors to participate.

Stakeholder-centred design and participation therefore operate as a cross-cutting governance process, rather than as an additional substantive dimension. The framework emphasises dynamic stakeholder mapping, meaningful inclusion, equity and justice, early engagement and mechanisms through which stakeholder input can genuinely inform research, project design and governance conditions. Participation should not be designed simply to generate acceptance or consensus; disagreement over uncertainty, environmental risks, commercial interests and acceptable pathways may itself constitute important governance information.

Main conclusions

A central conclusion is that scale-up should be treated as a conditional governance decision rather than as the automatic outcome of successful research or technological development. Progression from research to field experimentation and potentially larger-scale activity should depend on the accumulation of sufficient scientific evidence, credible environmental monitoring and carbon-removal MRV, regulatory and institutional capacity, continuing legitimacy and appropriate arrangements for allocating environmental and financial risks. Where these conditions are not met, legitimate governance outcomes may include continued research, modification of an intervention, additional safeguards, temporary suspension or non-progression.

No single governance dimension provides the foundation for the others. Legal permissibility, ethical and social legitimacy, scientific readiness, economic support and institutional capacity address different but interdependent governance questions. Effective mCDR governance therefore requires a coherent and adaptive architecture capable of enabling learning while preserving precaution, accountability and the possibility of revising decisions as technologies, evidence and societal expectations evolve.

Main recommendations

At the EU level, the deliverable recommends continuing to develop and refine evidence-based, technique-specific pathways for the possible inclusion of relevant mCDR approaches under the Carbon Removal Certification Framework (CRCF), building on ongoing technical work and stakeholder consultation and allowing requirements to evolve as scientific evidence, monitoring approaches and governance experience develop. It further recommends strengthening cross-sectoral coordination between climate, marine, environmental, research and innovation policy; aligning research, innovation and financial support with stage-specific scientific and governance readiness; and embedding meaningful participation, equity and legitimacy in research, authorisation and support processes.

At the international level, priorities include stronger consideration of mCDR within relevant Paris Agreement processes supported by credible and interoperable MRV; convergence on definitions, legal characterisation and minimum governance safeguards; improved transparency and information-sharing; inclusive international Communities of Practice and capacity-building; and clearer expectations concerning accountability, liability and financial-security arrangements. The framework also emphasises the need to address inequalities in scientific, technical and regulatory capacity and to ensure meaningful participation of developing countries, Small Island Developing States, coastal communities and other actors with comparatively limited institutional influence.

Overall, D5.2 proposes a governance model that is neither designed to accelerate mCDR irrespective of risk nor to prevent experimentation by default. Its purpose is to establish **credible, adaptive and context-sensitive pathways through which research and potential progression can be assessed against scientific evidence, environmental integrity, legal requirements, justice and legitimacy, economic conditions and institutional capacity.**

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1 List of Abbreviations

ABNJ	Areas Beyond National Jurisdiction
BBNJ	Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction
BCR	Biochar Carbon Removal
BioCCS	Biogenic Emissions Capture with Carbon Storage
CBD	Convention on Biological Diversity
CCfD	Carbon Contract for Difference
CDR	Carbon Dioxide Removal
CPr	Communities of Practice
CRCF	Carbon Removal Certification Framework
D	Deliverable
DACCS	Direct Air Capture with Carbon Storage
DG CLIMA	Directorate-General for Climate Action
DG MARE	Directorate-General for Maritime Affairs and Fisheries
EEZ	Exclusive Economic Zone
EGD	European Green Deal
EIA	Environmental Impact Assessment
EU	European Union
GDPR	General Data Protection Regulation
HELCOM	Baltic Marine Environment Protection Commission (Helsinki Commission)
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
LC/LP	London Convention and London Protocol
mCDR	Marine- Carbon Dioxide Removal
MRV	Monitoring, Reporting and Verification
NETs	Negative Emission Technologies
NGO	Non-Governmental Organization
OAE	Ocean Alkalinity Enhancement
OCDR	Ocean-based Carbon Dioxide Removal
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
RIA	Research and Innovation Action
SEA	Strategic Environmental Assessment
tCDR	Terrestrial Carbon Dioxide Removal
UNCLOS	United Nations Convention on the Law of the Sea
UNFCCC	United Nations Framework Convention on Climate Change
WP	Work Package

2 Introduction

Marine carbon dioxide removal (mCDR) is receiving increasing attention as part of the wider portfolio of approaches that may contribute to achieving climate-neutrality objectives. Carbon dioxide removal will be required to counterbalance residual emissions in pathways towards net-zero emissions, but it cannot substitute for rapid and sustained emissions reductions. At the same time, mCDR encompasses a heterogeneous group of approaches that differ substantially in technological maturity, removal potential and durability, environmental effects, spatial characteristics and governance requirements. Their interaction with dynamic marine ecosystems, multiple uses of ocean space and different jurisdictional regimes makes their governance particularly complex.

This deliverable builds directly on D5.1, *Legal, ethical and policy implications of OCDR*, which established the legal, ethical, political and geopolitical foundations for the governance work undertaken in WP5. D5.1 demonstrated that mCDR does not operate in a legal vacuum: existing international obligations already establish requirements concerning environmental assessment, due diligence, monitoring, transparency and international cooperation. It also showed that mCDR cannot be treated as a legally uniform category, as different technique families engage different regulatory gateways and accountability requirements. Importantly, potential progression towards larger-scale activity was identified as a threshold problem in which legal scrutiny, due-diligence requirements and demands on institutional capacity intensify as the scale, environmental footprint, foreseeability of harm and transboundary reach of an intervention increase.

D5.2 takes the next step by translating these findings into a scientifically grounded, stakeholder-oriented and multi-dimensional governance framework. The central premise is that responsible mCDR governance needs to be technique-specific, stage- and scale-sensitive, adaptive and multi-level, combining common principles and safeguards with differentiated requirements appropriate to particular interventions. Governance should enable legitimate research and learning without creating a presumption of subsequent deployment and should preserve the possibility of modifying, suspending or discontinuing activities where relevant conditions are not met.

The deliverable draws on a review of existing literature and relevant legal and policy instruments, together with evidence generated across SEAO2-CDR project activities. These project inputs include the legal, ethical and geopolitical findings of D5.1, scientific evidence from WPs 2 and 3, stakeholder and societal findings from WP4, commercial and market considerations from WP6, and expert and stakeholder contributions gathered through the WP5 CPr network. The CPr-related engagement brought together research, policy, civil-society and business perspectives through semi-structured interviews, consultations and three deliberative workshops (held in Warsaw, Rome and Madrid, with a combined attendance of 28 participants). A dedicated SEAO2-CDR subforum was also established within the UPTAKE CDR Stakeholder Forum[2] (with 273 members).[3] The CPr therefore provide an important link between the analytical and practical dimensions of the work by bringing legal and policy analysis into dialogue with institutional experience, stakeholder concerns and implementation challenges.

[2] https://forum.cdr-uptake.eu/

[3] See: Annex: Development of the Communities of Practice (CPr) network under Task 5.1. for more information.

The deliverable is presented in four sections. Chapter 3 defines the governance problem and examines the existing mCDR governance landscape, its principal gaps and cross-cutting barriers. Chapter 4 develops the core building blocks of the multi-dimensional framework across legal and regulatory arrangements; ethical and social acceptability; scientific knowledge, monitoring and uncertainty; economic incentives and risk-sharing; and institutional and multi-level governance. Chapter 5 develops the cross-cutting stakeholder-centred approach, focusing on stakeholder mapping, inclusion, equity and justice, and mechanisms for public engagement and co-creation. Chapter 6 brings these components together through guiding governance principles, and alternative governance pathways, before setting out policy and institutional recommendations at EU and international levels. The concluding chapter synthesises the principal implications for responsible and adaptive mCDR governance.

Through these processes, D5.2 moves beyond the identification of existing mCDR governance gaps towards the operationalisation of an integrated governance model for mCDR, by developing a framework capable of supporting coherent, adaptive and context-sensitive decision-making across different techniques, stages of development, scales and institutional settings. In doing so, it responds to the central question of Task 5.3: ***"if current governance practices are ineffective in promoting responsible mCDR deployment, what is the alternative?"***

3 Rethinking governance for mCDR: problem definition

Governance debates surrounding marine carbon dioxide removal mCDR are sometimes framed as a problem of technological development outpacing regulation. While this captures an important feature of the emerging landscape, it risks overstating the existence of a "governance vacuum". mCDR is already situated within a dense network of international legal obligations, regional and national environmental rules, climate-policy instruments, research norms and increasingly important voluntary and market-based arrangements. The principal problem is therefore less an absolute absence of governance than fragmentation, incomplete coordination, regulatory ambiguity and uneven capacity to translate general governance obligations into decisions appropriate to particular techniques, scales and locations (Röschel and Neumann, 2023).

This deliverable consequently approaches the mCDR governance challenge as a problem of governability: rules and institutions exist, but they do not yet consistently translate into coherent, technique-specific and stage-sensitive pathways through which decision-makers can determine whether an activity should proceed, under what conditions, on the basis of what evidence, and subject to what mechanisms for monitoring, review or termination. This shifts the central question from "*which rules apply to mCDR?*" towards *"how can applicable legal, scientific, environmental, economic and societal requirements be integrated into legitimate and defensible decisions under uncertainty?".* Röschel and Neumann (2023), for example, demonstrate that ocean-based negative-emission approaches are already connected directly, implicitly and indirectly to multiple international environmental agreements. Their analysis shows both considerable existing governance coverage and important coordination gaps. More recently, Röschel (2025b) identified 100 governance challenges across 35 peer-reviewed studies and found that most could not be confined to a purely social, ecological or technological domain. Instead, governance problems predominantly arise at the intersections between these systems.

This integrated interpretation has become even more important as the field develops, with Baatz et al. (2025) distinguishing between the feasibility and desirability of mCDR options and between information gathering and normative evaluation, demonstrating why technological feasibility or measurable carbon removal cannot establish that an intervention should proceed. More recent synthesis done by Brun et al. (2026) similarly identifies persistent knowledge gaps, ecological and social risks and inadequate governance as mutually interconnected challenges rather than separate obstacles to deployment.

Taken together, these findings suggest that the governance challenge does not arise from a single regulatory or institutional gap, but from the interaction of several characteristics of mCDR: technological heterogeneity, scientific uncertainty, overlapping jurisdictions and regulatory regimes, differentiated distribution of risks and benefits, and the possibility that decisions taken at the research and pilot stages shape subsequent technological trajectories. This interpretation is consistent with the findings of Task 5.2 (D5.1), which showed that existing legal, ethical and geopolitical dimensions of mCDR governance are closely interdependent and are becoming increasingly consequential as activities move towards larger scales and greater transboundary reach.

The governance problem therefore arises from several overlapping features:

- First, mCDR techniques operate across multiple spatial and jurisdictional scales. Activities may take place within national waters, in exclusive economic zones (EEZs), or on the high seas, raising issues of sovereignty, international coordination and the governance of global commons (Lebling & Savoldelli, 2025).
- Second, mCDR is governed through a combination of existing international, regional and national legal regimes rather than through a single dedicated framework. This should not be interpreted as a legal vacuum: existing international obligations already establish substantive and procedural requirements relevant to mCDR, particularly in relation to environmental assessment, monitoring, transparency, precaution and international cooperation.[4] At the same time, different mCDR techniques may engage different regulatory gateways, while the applicable requirements become more demanding as scale, environmental footprint and transboundary reach increase. The governance challenge therefore lies not only in regulatory coverage, but in ensuring coherent and technique-specific application of overlapping regimes and translating general obligations into workable authorisation and oversight procedures.
- Third, governance challenges are not solely legal or institutional. Ethical and justice concerns, such as distributive impacts, risks of moral hazard and questions of procedural legitimacy, further complicate debates on mCDR and geoengineering more broadly (Röschel, 2025a). These concerns highlight the need to ensure that governance does not simply authorise or constrain technologies but actively shapes them in line with societal values, precautionary principles and the rights of potentially affected communities.
- Fourth, the political economy of mCDR adds further complexity. The prospect of deploying mCDR techniques raises geopolitical questions of responsibility, capacity and benefit-sharing. Wealthier states and actors with advanced technological capacities are better positioned to pursue mCDR, while vulnerable communities may bear disproportionate risks or be excluded from decision-making. These dynamics risk reinforcing global inequalities if governance arrangements are not carefully designed to promote inclusivity and fairness.
- Finally, the governance challenge is complicated by the temporal dimension of mCDR. Decisions taken today, whether in permitting research, shaping funding streams, or establishing pilot projects, may shape the course of future development, determining its scale and direction. In this sense, governance must not only respond to current gaps but also anticipate long-term uncertainties, providing adaptive and sustainable mechanisms that allow for learning, revision and course correction as scientific knowledge evolves.

The legal analysis undertaken in Task 5.2. (D5.1) provides an important baseline for this problem definition. First, it finds that mCDR is already subject to directly applicable international obligations rather than merely indirectly relevant principles. Second, it demonstrates that mCDR cannot be treated as a legally uniform category, as different technique families engage different regulatory gateways and procedural requirements. Third, it conceptualises potential scale-up as a threshold problem: regulatory requirements become progressively more demanding as the scale, footprint, foreseeability of harm and transboundary reach of an intervention increase. Finally, it shows that legally defensible authorisation depends not only on the formal existence of applicable rules, but also on adequate assessment,

[4] See D5.1 for more information.

monitoring, transparency, cooperation and sufficient institutional capacity to supervise and enforce conditions imposed on public and private operators.

Against this backdrop, and building on the legal, ethical and geopolitical findings, rethinking governance for mCDR requires moving beyond the analysis of individual governance dimensions towards understanding how these dimensions interact in practice. The challenge is not merely to establish regulatory compliance, but to develop a multidimensional governance architecture capable of integrating legal requirements, scientific evidence and uncertainty, environmental safeguards, economic incentives, institutional capacity and societal legitimacy. Accordingly, this chapter examines the current mCDR governance landscape (Section 3.1), identifies the principal gaps preventing existing arrangements from operating as a coherent governance system (Section 3.2), and derives the cross-cutting requirements that need to be addressed by the multi-dimensional framework (Section 3.3).

3.1 Overview of current mCDR governance landscape

This section maps the principal governance arrangements currently relevant to mCDR and examines how the different governance functions identified in the existing legal, policy and scientific landscape relate to one another. Legal analysis in D5.1 established that the governance requirements applicable to mCDR vary according to the character of the intervention and its stage and scale, rather than forming a single uniform regulatory pathway. A technique-family perspective was therefore adopted, structured around three recurring questions: the legal characterisation of the activity and the applicable regulatory gateway; the procedural safeguards required; and questions of accountability and the durability of removals. As activities increase in scale, environmental footprint or transboundary reach, the requirements associated with assessment, monitoring, cooperation and institutional supervision become progressively more demanding. Potential scale-up is consequently conceptualised through three interrelated thresholds: a regulatory gateway threshold, a due-diligence intensity threshold and an institutional-capacity threshold.

The differentiated approach is particularly important as the current mCDR governance landscape consists of multiple governance systems established for different purposes. For analytical purposes, these can be grouped into six principal governance functions: (i) marine environmental protection and authorisation; (ii) control of dumping, placement and marine geoengineering; (iii) biodiversity and areas beyond national jurisdiction; (iv) climate accounting and carbon-removal certification; (v) regional and domestic environmental governance; and (vi) scientific evidence, MRV and institutional oversight. These functions overlap, but they are not interchangeable: an activity may meet the requirements associated with one function while remaining unresolved under another.

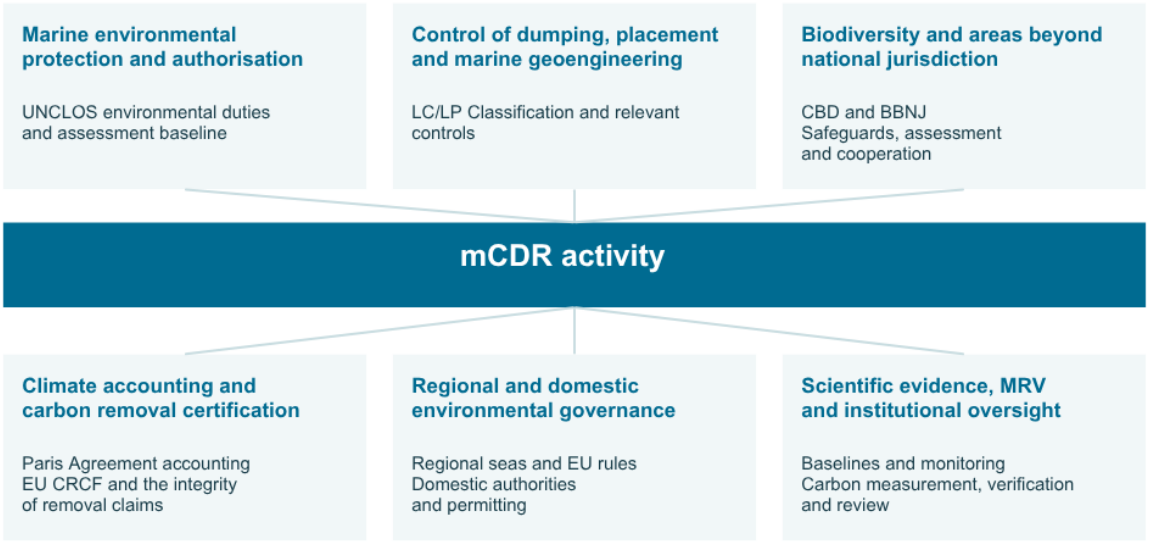

Figure 1. mCDR governance regime complex

At the broadest international level, the **UNCLOS** provides the overarching environmental framework within which mCDR activities must be considered. Part XII establishes the obligation to protect and preserve the marine environment (Article 192), requires States to take measures to prevent, reduce and control pollution of the marine environment (Article 194), provides for international cooperation and development of scientific criteria (Articles 197–201), and contains specific provisions on monitoring and assessment of activities that may affect the marine environment (Articles 204–206).[5] These obligations are general rather than mCDR-specific, but this is precisely what gives UNCLOS continuing relevance to emerging marine technologies: its procedural and environmental requirements do not depend on whether an activity had been anticipated when the Convention was negotiated. In practice, UNCLOS therefore functions as a cross-cutting environmental and procedural baseline, rather than as a complete mCDR-specific regulatory regime.

The London Convention and London Protocol (LC/LP) constitute the most developed international institutional framework specifically addressing marine geoengineering. Resolution LC-LP.1(2008)[6] introduced in relation to ocean fertilisation activities, established that activities other than legitimate scientific research should not be allowed, while the 2010 Assessment Framework for Scientific Research Involving Ocean Fertilization[7] introduced substantive criteria for determining whether proposed experiments qualify as legitimate research - this established an important governance precedent whereby the research status of an activity depends on substantive assessment rather than solely on how it is

[5] United Nations. (1982). United Nations Convention on the Law of the Sea. Montego Bay, 10 December 1982, 1833 UNTS 397, particularly Part XII. https://www.un.org/depts/los/convention_agreements/texts/unclos/part12.htm

[6] International Maritime Organization (IMO). (2008). Resolution LC-LP.1(2008), On the Regulation of Ocean Fertilization, adopted 31 October 2008. The Resolution states that ocean fertilisation activities other than legitimate scientific research should not be allowed. https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/LCLPDocuments/LC-LP.1%20%282008%29.pdf

[7] International Maritime Organization (IMO). (2010). Resolution LC-LP.2(2010), On the Assessment Framework for Scientific Research Involving Ocean Fertilization, adopted 14 October 2010. https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/OFassessmentResolution.pdf

characterised by its proponent. In 2013, Resolution LP.4(8) [8] sought to extend this approach through a broader marine-geoengineering framework based on Article 6bis and a positive-list mechanism under Annexes 4 and 5. Ocean fertilisation is currently the only activity listed, although the architecture could in principle be extended to other techniques. The amendment has not yet entered into force and, as of the latest completed LC/LP meeting in October 2025, had been accepted by nine Parties.[9] This should be distinguished from the London Protocol's established framework for sub-seabed CO_2 storage: the 2006 amendment allowing qualifying CO_2 streams to be stored in sub-seabed geological formations entered into force in 2007, while the 2009 amendment facilitating transboundary export of CO_2 streams remains formally not yet in force but may be provisionally applied by participating Parties under the 2019 resolution.

More recently, LC/LP work has expanded beyond ocean fertilisation. In 2024, Parties prioritised OAE, ocean sinking of biomass for carbon storage, marine surface-albedo enhancement and marine cloud brightening for further legal and technical consideration, with the first two directly relevant to mCDR.[10] In 2025, the governing bodies also drew attention to the growing involvement of private and commercial actors and to possible environmental, social and economic implications, particularly for developing countries, Least Developed Countries and Small Island Developing States. Further intersessional work remains ongoing.[11] Taken together, these developments suggest that the LC/LP is evolving from a framework centred principally on ocean fertilisation towards a broader anticipatory governance forum for emerging marine interventions, even though the binding architecture envisaged by the 2013 amendment is not yet in force. Röschel (2026) similarly identifies the LC/LP as an important institutional anchor for precautionary mCDR governance, while questioning whether conventional pollution-based approaches are sufficient to capture the wider social-ecological implications of mCDR (Röschel, 2026).

The Convention on Biological Diversity (CBD) in Decision X/33[12], building on Decision IX/16 C[13] concerning ocean fertilisation, calls on Parties and other governments, consistently with the precautionary approach, to ensure that climate-related geoengineering activities that may affect biodiversity do not proceed in the absence of an adequate scientific basis and appropriate consideration of associated environmental, biodiversity, social, economic and cultural risks. The decision provides an exception for justified small-scale scientific research conducted in a controlled setting and subject to prior assessment.[14] The legal

[8] International Maritime Organization (IMO). (2013). Resolution LP.4(8), Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and Other Marine Geoengineering Activities, adopted 18 October 2013. https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/LCLPDocuments/LP.4(8).pdf

[9] International Maritime Organization (IMO). (2026). Status of IMO Treaties: Comprehensive information on the status of multilateral Conventions and instruments in respect of which the International Maritime Organization or its Secretary-General performs depositary or other functions, updated 26 August 2026, pp. 604–605. https://wwwcdn.imo.org/localresources/en/About/Conventions/StatusOfConventions/Status%202026.pdf

[10] International Maritime Organization (IMO). (2024). 46th Consultative Meeting of Contracting Parties to the London Convention and the 19th Meeting of Contracting Parties to the London Protocol (LC 46/LP 19), 28 October–1 November 2024.https://www.imo.org/en/mediacentre/meetingsummaries/pages/lc-46-lp-19.aspx

[11] International Maritime Organization (IMO). (2025). 47th Consultative Meeting of Contracting Parties to the London Convention and the 20th Meeting of Contracting Parties to the London Protocol (LC 47/LP 20), 27–31 October 2025. meeting summary, 28 October–1 November 2024. https://www.imo.org/en/mediacentre/meetingsummaries/pages/lc-47-lp-20.aspx

[12] Convention on Biological Diversity (CBD). (2010). Decision X/33, Biodiversity and Climate Change, particularly para. 8(w). https://www.cbd.int/decision/cop?id=12299

[13] Convention on Biological Diversity (CBD). (2008). Decision IX/16, Biodiversity and Climate Change, Section C: Ocean Fertilization. https://www.cbd.int/decision/cop?id=11659

[14] Convention on Biological Diversity (CBD). (2008). Decision IX/16 C, Biodiversity and Climate Change: Ocean Fertilization; Convention on Biological Diversity. (2010). Decision X/33, Biodiversity and Climate Change, para. 8(w); Convention on Biological Diversity. (2024). Decision 16/22,

nature of these decisions is important, as they should not be presented as a universally binding prohibition on mCDR. Their governance significance lies instead in establishing a strong precautionary benchmark linking justification of intervention to scientific evidence, prior assessment and consideration of a broader range of consequences. This approach has remained on the CBD agenda: at COP16, the Conference of the Parties reaffirmed Decision IX/16 C on ocean fertilisation, paragraph 8(w) of Decision X/33, and Decisions XI/20 and XIII/14 on climate-related geoengineering, and urged Parties, while encouraging other Governments, to ensure their implementation.

A more substantial institutional development concerns **governance of areas beyond national jurisdiction (ABNJ)**. The Agreement under UNCLOS on the **Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ Agreement)**[15] was adopted in June 2023 and entered into force on 17 January 2026. As of September 2026, it is therefore no longer a prospective governance development but an operative treaty framework for its Parties. The BBNJ Agreement addresses four principal areas: marine genetic resources and benefit-sharing; area-based management tools, including marine protected areas; environmental impact assessments; and capacity-building and transfer of marine technology. It is not an mCDR treaty, and its relevance to individual activities will depend on the circumstances and applicable provisions. Nevertheless, future mCDR activities occurring in, or potentially affecting, ABNJ may interact with its environmental assessment and institutional arrangements. Its capacity-building and technology-transfer provisions are also relevant to the wider governance problem concerning unequal scientific and regulatory capacity between States. The BBNJ Agreement does not replace existing competent international or sectoral bodies. Its entry into force therefore does not eliminate fragmentation; rather, it adds a further binding institutional layer whose effectiveness will depend partly on interaction with UNCLOS, LC/LP, IMO processes and other regional or sectoral arrangements. In this sense, BBNJ strengthens the available procedural architecture while simultaneously increasing the importance of institutional coordination and regime interfaces.

While the preceding regimes focus predominantly on the permissibility and environmental consequences of marine intervention, a separate but increasingly important governance function concerns the integrity of the resulting carbon-removal claim.

Within the climate governance regime, the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement recognise the importance of "removals by sinks," although without explicitly addressing ocean-based approaches. **Article 4 of the Paris Agreement**[16] establishes the long-term objective of achieving a balance between anthropogenic greenhouse-gas emissions by sources and removals by sinks in the second half of this century. This provides the overarching climate-policy context in which carbon removals are considered, but it does not constitute an authorisation framework for particular mCDR activities. The climatic value of an intervention and its environmental permissibility therefore remain distinct governance questions. In October 2024, the Article 6.4 Supervisory Body

Biodiversity and Climate Change, para. 6. Decision X/33 calls for a precautionary approach to climate-related geoengineering that may affect biodiversity in the absence of an adequate scientific basis, with a limited exception for justified small-scale scientific research subject to prior assessment; Decision 16/22 reaffirms Decisions IX/16 C, X/33, XI/20 and XIII/14.

[15] United Nations. (2023). Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction. Adopted 19 June 2023; entered into force 17 January 2026. https://www.un.org/bbnjagreement/en

[16] United Nations Framework Convention on Climate Change (UNFCCC). (2015). Paris Agreement. Paris, 12 December 2015, particularly Art. 4(1). https://unfccc.int/sites/default/files/english_paris_agreement.pdf

adopted a dedicated standard containing requirements for activities involving removals.[17] This has been supplemented by methodological standards addressing baselines, leakage, non-permanence and reversals, and additionality. Version 2.0 of the additionality standard was adopted in May 2026.[18]

These developments mean that the climate-governance domain should no longer be described as a complete accounting or MRV vacuum - there is now an increasingly developed general architecture for dealing with the integrity of removals. At the same time, these standards do not constitute an approved mCDR-specific methodology. Questions concerning marine baselines, attribution of atmospheric uptake, ocean transport and mixing, durability, environmental effects and other technique-specific features continue to require dedicated methodological development. A similar distinction is visible at the **regional level** in the European Union (EU).

Regulation (EU) 2024/3012[19], establishing the **Carbon Removals and Carbon Farming Certification Framework (CRCF)**, defines carbon removal as anthropogenic removal of carbon from the atmosphere followed by durable storage in geological, terrestrial or ocean reservoirs, or in long-lasting products. The Regulation establishes quality requirements concerning quantification, additionality, storage, liability and sustainability. However, inclusion of ocean reservoirs within this general definition does not mean that mCDR approaches are already operationally certifiable under the CRCF. Commission Delegated Regulation (EU) 2026/285[20] established the first methodologies for permanent carbon-removal activities, covering direct air capture with carbon storage (DACCS), biogenic emissions capture with carbon storage (BioCCS), and biochar carbon removal (BCR). The Commission's recitals explicitly identify these three approaches as those for which scientific knowledge and technological maturity were considered sufficient to develop robust and transparent methodologies. Marine approaches are, however, moving onto the methodological agenda, as the Commission published a review of Ocean Alkalinity Enhancement (OAE) in February 2026 and a review of Direct Ocean Carbon Capture and Storage (DOCCS) in June 2026, and currently lists both among possible future permanent-removal pathways alongside enhanced rock weathering and mineralisation.[21] These reviews indicate increasing policy attention but should not be confused with adoption of certification methodologies. The emerging relationship between marine governance and carbon-removal certification therefore illustrates one of the clearest interfaces in the mCDR regime complex. Carbon certification cannot substitute for environmental authorisation, while environmental authorisation does not itself establish that an intervention has generated an additional, quantifiable and sufficiently durable atmospheric carbon removal. The two governance functions may depend on overlapping scientific information and monitoring systems, but they answer different questions and should remain distinct while being designed to interact coherently.

[17] UNFCCC Article 6.4 Supervisory Body. (2024). Requirements for activities involving removals under the Article 6.4 mechanism, ver. 01.0, A6.4-STAN-METH-002, 9 October 2024. https://unfccc.int/documents/641297

[18] UNFCCC Article 6.4 Supervisory Body. (2026). Demonstration of additionality in mechanism methodologies, ver. 02.0, A6.4-STAN-METH-003, 21 May 2026. For items 22–25: https://unfccc.int/process-and-meetings/bodies/constituted-bodies/article-64-supervisory-body/rules-and-regulations

[19] European Parliament and Council of the European Union. (2024). Regulation (EU) 2024/3012 of 27 November 2024 establishing a Union certification framework for permanent carbon removals, carbon farming and carbon storage in products. Official Journal of the European Union, 6 December 2024. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32024R3012

[20] European Commission. (2026). Commission Delegated Regulation (EU) 2026/285 of 3 February 2026 supplementing Regulation (EU) 2024/3012 by establishing certification methodologies for permanent carbon-removal activities. Official Journal of the European Union, 17 April 2026. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32026R0285

[21] European Commission, Directorate-General for Climate Action. (2026). Certification methodologies – Permanent carbon removals. https://climate.ec.europa.eu/eu-action/carbon-removals-and-carbon-farming/certification-methodologies_en

Within the EU, mCDR activities may additionally interact with an established environmental and marine governance acquis. Depending on the characteristics, scale and location of an intervention, relevant instruments may include the Environmental Impact Assessment Directive (Directive 2011/92/EU, as amended by Directive 2014/52/EU)[22], Marine Strategy Framework Directive (Directive 2008/56/EC)[23], Water Framework Directive (Directive 2000/60/EC)[24], Habitats Directive (Directive 92/43/EEC)[25], and Maritime Spatial Planning Directive (Directive 2014/89/EU).[26] The institutional implication is especially important: considerable administrative machinery already exists for assessing marine activities and protecting environmental quality, but responsibilities and objectives are spread across several legal instruments and competent authorities.[27]

The European Ocean Pact[28], adopted in June 2025, adds a broader strategic coordination framework. The Pact is structured around six priorities covering ocean health; competitiveness of the sustainable blue economy; coastal and island communities; ocean research, knowledge, skills and innovation; maritime security and defence; and international ocean governance. It also explicitly identifies the need for stronger governance capable of aligning action across Union, regional, national and local levels and across sea basins. The forthcoming European Ocean Act may further strengthen this horizontal coordination function. As of September 2026, it remains a legislative initiative rather than adopted law. The Commission's current planning describes it as a proposed directive intended to establish a governance framework for implementation of the Ocean Pact and to amend the Maritime Spatial Planning Directive. The initiative is intended, inter alia, to strengthen cross-sectoral coordination, modernise maritime spatial planning, improve ocean-observation governance and provide a clearer framework for implementing existing ocean-related objectives. The Commission's current indicative timetable is the fourth quarter of 2026.[29]

Below the EU-wide level, regional seas arrangements add a further geographically specific governance layer. The OSPAR Convention (OSPAR Decision 2007/1) prohibits the storage of CO_2 in the water column or seabed within its jurisdiction.[30] Other regional seas conventions, such as the 1992 Helsinki Convention

[22] European Parliament and Council of the European Union. (2011). Directive 2011/92/EU of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment. OJ L 26, 28 January 2012, https://eur-lex.europa.eu/eli/dir/2011/92/oj/eng; European Parliament and Council of the European Union. (2014). Directive 2014/52/EU of 16 April 2014 amending Directive 2011/92/EU. OJ L 124, 25 April 2014, https://eur-lex.europa.eu/eli/dir/2014/52/oj/eng

[23] European Parliament and Council of the European Union. (2008). Directive 2008/56/EC of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive). OJ L 164, 25 June 2008. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0056

[24] European Parliament and Council of the European Union. (2000). Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy. OJ L 327, 22 December 2000. https://eur-lex.europa.eu/eli/dir/2000/60/oj/eng

[25] Council of the European Communities. (1992). Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. OJ L 206, 22 July 1992. https://eur-lex.europa.eu/eli/dir/1992/43/oj

[26] European Parliament and Council of the European Union. (2014). Directive 2014/89/EU of 23 July 2014 establishing a framework for maritime spatial planning. OJ L 257, 28 August 2014. https://eur-lex.europa.eu/eli/dir/2014/89

[27] D5.1 examines the legal relevance of the principal environmental instruments in greater detail.

[28] European Commission. (2025). The European Ocean Pact. COM(2025) 281 final, 5 June 2025. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=comnat:COM_2025_0281_FIN

[29] European Commission. (2026b). *European Ocean Act: Preparatory and consultation materials*. https://oceans-and-fisheries.ec.europa.eu/european-ocean-pact_en

[30] OSPAR Commission. (2007). OSPAR Decision 2007/1 to Prohibit the Storage of Carbon Dioxide Streams in the Water Column or on the Sea-bed (OSPAR 07/25/1, Annex 5). https://www.ospar.org/documents?v=32641.

(HELCOM)[31] or the Barcelona Convention,[32] contain precautionary provisions that may limit mCDR practices with ecological risks. The wider implication is that regional governance can impose requirements that are more specific than the general international baseline, while those requirements differ between marine regions.

The comparative governance coverage of selected mCDR technique families presented below (Table 1) highlights that governance maturity varies both between technologies and between governance functions. Ocean fertilisation has a comparatively developed international framework for determining whether research may proceed, but this does not imply the existence of a mature carbon-accounting or certification pathway. OAE, by contrast, is increasingly being considered both within LC/LP marine-governance processes and within EU carbon-removal methodology development, while the interface between these two governance domains remains unsettled.

Governance regime or function	OAE	Macroalgae cultivation	Biomass sinking	Artificial upwelling	Ocean iron fertilisation
UNCLOS	Applicable general baseline	Applicable general baseline	Applicable general baseline	Applicable general baseline	Applicable general baseline
London Protocol	Under active consideration	Generally indirect or configuration-dependent	Potentially significant applicability	No dedicated LP framework at present	Most developed specialised framework
CBD	Precautionary relevance	Relevant through biodiversity and ecosystem safeguards	Precautionary biodiversity relevance	Precautionary relevance	Strong precautionary treatment
BBNJ	Potentially relevant	Potentially relevant	Potentially relevant	Potentially relevant through EIA and cooperation provisions	Potentially relevant

[31] Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention). (1992). https://www.helcom.fi/wp-content/uploads/2019/06/Helsinki-Convention_July-2014.pdf

[32] United Nations Environment Programme/Mediterranean Action Plan. (n.d.). *Mediterranean Action Plan*. Retrieved September 16, 2026, from https://www.unep.org/unepmap/

Governance regime or function	OAE	Macroalgae cultivation	Biomass sinking	Artificial upwelling	Ocean iron fertilisation
EU CRCF (2024/3012)	Under methodological consideration	No adopted dedicated methodology	No adopted methodology	No adopted methodology	No adopted methodology
OSPAR and regional seas	Project- and region-specific	Strongly region-specific	Potentially constrained by regional dumping rules	Region- and project-specific environmental rules may apply	Regional marine pollution and dumping rules may impose additional restrictions
Coverage summary	Increasing governance attention, but important classification and coordination gaps remain	Governed mainly through existing sectoral regimes; climate-removal status remains less developed	Fragmented and highly dependent on legal classification, storage pathway and project design	Limited technique-specific governance; relies mainly on general marine environmental frameworks	Narrower but comparatively clearer governance, particularly for scientific research

Table 1. Comparative governance coverage of selected mCDR technique families (summary)

Note: This table provides a high-level summary of selected governance arrangements relevant to different mCDR technique families. It is not an exhaustive assessment of applicable requirements, which depend on the characteristics, location and scale of an activity.

At the **national level**, the emerging governance landscape is highly heterogeneous and is better understood in terms of asymmetric governance readiness than through a simple distinction between regulated and unregulated jurisdictions. The absence of dedicated mCDR legislation does not necessarily imply an absence of governance: proposed activities may already fall within existing regimes governing marine pollution and dumping, water discharges, environmental impact assessment, biodiversity protection, marine spatial planning and, where relevant, geological CO_2 storage. Conversely, the existence of comparatively developed regulation for one activity or part of the carbon-management chain does not imply equivalent governance readiness across all mCDR techniques or stages of development. Table 2 illustrates this variation through the national case studies examined in D5.1.[33] The cases were selected in to explore different emerging regulatory approaches and therefore provide illustrative rather than globally representative examples. They are concentrated in Europe and North America and should not be interpreted as a comprehensive comparison of national mCDR governance worldwide; rather, they demonstrate how different jurisdictions combine existing environmental and sectoral regulation, emerging mCDR-specific provisions, research support and enabling policies in different ways.

[33] See D5.1. for more information.

Country	Overall approach (restrictive/ permissive/ supportive)	Main characteristics of the national approach	Key governance features
Canada	Restrictive	Precautionary, reverse-listing approach; no bespoke mCDR framework; narrow scope for authorised activities.	Existing disposal-at-sea rules provide strong regulatory gatekeeping, while broader carbon-management and innovation support is developing.
Netherlands	Restrictive, with some permissive features	Dense water, environmental, nature and planning regulation; selected mCDR approaches receiving increasing policy attention.	Authorisation is largely channelled through existing permitting and EIA regimes; innovation interest is emerging alongside comparatively restrictive regulatory conditions.
Germany	Moving towards more permissive treatment for selected pathways	Restrictive treatment of several marine geoengineering activities combined with expanding regulation for offshore CO_2 transport and storage.	Regulatory maturity differs substantially by technique: offshore storage is increasingly enabled while other marine interventions remain constrained.
Norway	Permissive	No specific mCDR framework or comprehensive prohibition; established CCS regulation and ongoing pilot activity.	Existing sectoral frameworks create space for research and development, although mCDR is not yet explicitly supported as a distinct policy field.
United Kingdom	Permissive, particularly for research and demonstration	No bespoke mCDR legislation; activities rely on broader climate, marine and environmental law.	Existing regulatory regimes provide pathways for project-specific research and demonstration despite the absence of dedicated mCDR regulation.
United States	Supportive	No comprehensive mCDR statute, but strong federal research support, dedicated strategy and significant public funding.	Existing environmental permitting mechanisms operate alongside an increasingly explicit promotional framework for mCDR research and future development.

Table 2. National regulatory approaches to mCDR in selected case-study jurisdictions

Note: This table has been developed based on D5.1. The classification (overall approach) follows the comparative typology developed in D5.1. Restrictive approaches take a precautionary view and impose constraints, moratoria or prohibitions on particular techniques; permissive approaches are characterised by the absence of a general prohibition and by recognition of at least some mCDR-related uses; and supportive approaches additionally encourage scientific research and, in some cases, provide financial support for technological development and potential scale-up. These categories describe prevailing regulatory postures rather than fixed national models.

The comparison shows that national governance rarely takes the form of a single bespoke regulatory framework covering the full range of mCDR techniques and stages of development. Instead, governance readiness is technique-, function- and stage-dependent. The broader pattern is consistent with the assessment by the National Academies of Sciences, Engineering, and Medicine (2026), which characterises national mCDR governance as a combination of pre-existing legal frameworks and emerging purpose-built provisions, also pointing out the limited geographical coverage of existing comparative research, particularly in relation to the Global South. However, research, as well as international collaboration on mCDR, also extends beyond the Global North; for example, the Global Ocean Negative Carbon Emissions (Global ONCE)[34] programme is led by Xiamen University in China and endorsed under the UN Decade of Ocean Science for Sustainable Development. Such initiatives further underline the need for broader comparative analysis as national approaches continue to evolve.

[34] https://www.global-once.org/#/home

The relevant distinction is therefore not simply between the presence and absence of regulation, but between **different combinations of authorisation capacity, evidence-generation and oversight capacity, and promotional capacity**. This distinction has become increasingly important as mCDR research moves from laboratory and modelling studies towards field experimentation. Recent empirical evidence concerning novel marine-climate interventions identifies a broader "pacing problem", whereby experimentation can advance more rapidly than governance arrangements capable of anticipating and managing its environmental and societal implications. Ogier et al. (2025), based on a survey of 332 practitioners working across 37 marine systems, found that decision-making remained strongly oriented towards technical feasibility and minimum permitting requirements, while arrangements for ethics assessment, accountability and transparency, co-production with Indigenous Peoples and local communities, and management of social impacts were much less frequently reported. This suggests that the existence of a legal route to authorisation is not, in itself, evidence of governance preparedness. Other recent mCDR assessments similarly emphasise the need for adaptive legal, policy, research and monitoring frameworks and for governments to develop clear, science-based permitting pathways capable of evolving as evidence and scale change (Johnson et al., 2024).

3.2 Key governance gaps and failures

The most pressing governance gaps in the current mCDR landscape stem not only from the absence of a comprehensive regulatory framework but also from the **geopolitical tensions shaping international environmental governance**. As explained above, existing instruments- UNCLOS, LC/LP, the CBD, and the BBNJ Agreement- offer only partial coverage, as they were designed primarily for marine environmental protection or biodiversity conservation rather than climate mitigation. Their limited relevance to mCDR creates interpretive uncertainty: should techniques such as OAE, large-scale seaweed farming, or artificial upwelling be understood as legitimate climate mitigation, potential pollutants, or marine geoengineering? This ambiguity is amplified by geopolitical rivalries, as states may strategically frame mCDR either as a climate necessity or as an ecological threat, depending on their interests, technological capacity, and negotiating positions in broader climate diplomacy.

The London Protocol illustrates the combined regulatory and political challenges. Its 2009 and 2013 have not yet entered into force, reflecting not only procedural inertia but also diverging geopolitical interests. Emerging mCDR methods fall into a grey zone, generating regulatory asymmetries that may be exploited by states or private actors. Similarly, while CBD decisions apply a precautionary approach, their non-binding nature leaves space for powerful states or alliances to pursue unilateral or regional initiatives, potentially sidelining smaller or less technologically advanced states. These dynamics risk entrenching power asymmetries and fostering competition rather than cooperation.

In the climate regime, translating the Paris Agreement's recognition of removals by sinks without clear rules for ocean-based approaches poses a further challenge. mCDR approaches are assessed in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2022); however, their discussion should not be confused with their representation in modelled mitigation pathways, where CDR options are mostly limited to bioenergy with carbon capture and storage (BECCS), afforestation and direct air carbon capture and storage (DACCS). For mCDR, unresolved methodological questions concerning quantification, durability and attribution complicate the development of credible monitoring, reporting and verification (MRV), creating risks of inconsistent claims and double counting if accounting safeguards are inadequate. These challenges also have geopolitical implications: differences in scientific, technological and regulatory capacity may enable some states to exert greater influence over emerging

standards and markets, while others have fewer opportunities to shape them. Without transparent accounting, inclusive cooperation and a clear commitment to emissions reductions, the promotion of mCDR could therefore reinforce concerns about unequal influence and the use of removals to defer mitigation.

Regional and national governance also reveal **a mix of regulatory gaps and geopolitical contestation**. While instruments like the OSPAR Convention restrict certain CO_2 storage options relevant to mCDR, they do not address the broader range of techniques, leaving technique-specific questions to be assessed under other applicable international, regional and domestic rules. The EU's new certification framework for carbon removals may strengthen coherence within Europe, but it raises questions about alignment with global norms and its impact on international competitiveness. At the national level, countries such as Norway and the United States are advancing domestic frameworks and research, positioning themselves at the forefront of mCDR development. Yet this uneven regulatory engagement risks fragmentation, regulatory arbitrage, and geopolitical competition over technological leadership. Private actors may exploit such fragmentation to conduct experiments in permissive jurisdictions, while states may use mCDR capacity as a bargaining chip in climate and trade negotiations.

Finally, the ethical and normative governance frameworks, such as the Oxford Principles, have not been mainstreamed into legal systems, leaving gaps in technique-specific standards and their coordinated implementation. This vacuum does not exist in isolation but is shaped by **global power struggles**: the absence of agreed principles enables states to selectively invoke precaution or innovation depending on strategic interests. Taken together, the governance landscape is characterised by gaps in scope, enforceability, institutional coordination, and geopolitical alignment. Without clear, legitimate, and adaptive rules that integrate both legal oversight and geopolitical realities, the risk is either over-constraining research due to precautionary bans or enabling premature, poorly regulated deployment in a context of strategic competition, with potentially profound ecological and political consequences.

3.3 Cross-cutting barriers to deployment

In addition to specific regulatory gaps, there are broader cross-cutting barriers that impede the responsible development and deployment of mCDR. A first major barrier is **definitional ambiguity**. There is no shared understanding of what constitutes mCDR as distinct from marine geoengineering, ocean fertilisation, or more conventional forms of ocean management, such as aquaculture. This lack of conceptual clarity hinders the design of consistent legal frameworks, complicates the integration of mCDR into climate governance under the Paris Agreement, and generates confusion among policymakers, industry, and the public. It also fuels polarised debates: advocates frame mCDR as an essential climate mitigation tool, while critics equate it with risky geoengineering. Without conceptual alignment, governance discussions remain mired in contention rather than focusing on practical pathways for responsible research and oversight.

A second barrier lies in the **challenges of MRV**. Unlike terrestrial carbon dioxide removal (tCDR), ocean-based approaches are difficult to monitor, given the complexity and dynamism of marine systems. The dispersion of carbon across ocean layers, uncertainties in permanence, and risks of leakage back into the atmosphere complicate the establishment of robust accounting methodologies. Unequal global scientific and monitoring capacity risks creating "knowledge geopolitics," where definitions of permanence, leakage, or MRV standards are shaped disproportionately by technologically advanced states and institutions. This can lock-in specific methodologies, marginalising local knowledge systems, especially

from the Global South. This concern reinforces the importance of inclusive knowledge exchange and capacity-building through CPr (see Section 4.3 and Recommendation 8 in Section 6.3).

Financial, political, and ethical factors constitute additional barriers. From a **financial perspective**, mCDR technologies are expensive, unproven at scale, and currently still less attractive to private investors compared to terrestrial removals such as afforestation or direct air capture. Political support remains hesitant, with governments wary of being perceived as endorsing untested or risky geoengineering interventions. **From an ethical perspective, mCDR is entangled in debates about moral hazard, distributive justice, and intergenerational equity**. Critics argue that premature deployment could divert attention from emissions reductions, disproportionately impact vulnerable communities dependent on marine ecosystems, and externalise risks onto the Global South, where governance capacity may be weakest. These concerns undermine social license to operate and reinforce calls for precautionary moratoria, further constraining progress.

Institutional fragmentation is another cross-cutting barrier. The governance of mCDR spans multiple domains: climate, marine environment, biodiversity, trade, and human rights, yet there is little coordination across institutions. This creates the already-described overlaps, contradictions, and jurisdictional disputes. For instance, a single mCDR project might simultaneously fall under the purview of UNCLOS, the London Protocol, CBD, and regional conventions, each with different standards and enforcement mechanisms. Without mechanisms for cross-regime coordination, states and private actors are left navigating an incoherent system, discouraging investment and innovation. At the national level, overlapping mandates among environment, climate, energy, and maritime authorities further complicate policy development and licensing procedures.

A further barrier concerns **the alignment of regulatory, promotional and knowledge-generating functions**. Relevant questions include whether research funding generates evidence that can inform regulatory decisions; whether permitting requirements provide sufficiently clear conditions for responsible experimentation; whether MRV and transparency requirements accompany public support; and whether movement from research towards larger-scale testing is matched by corresponding changes in regulatory scrutiny, institutional capacity and financing arrangements. The consistency of policy elements (the extent to which objectives and instruments reinforce rather than undermine one another) and the coherence of policy processes (understood in terms of systematic and coordinated policymaking and implementation) should be distinguished, together with recognition of the temporal dimension of policy mixes (recognising that relationships between instruments may change as technologies, knowledge and institutional conditions evolve) (Rogge & Reichardt, 2016). Alignment should therefore not be understood as a one-off feature of policy design, but as a continuing governance requirement across institutions, instruments and stages of technological development and can itself be understood as a cross-cutting governance function: the capacity to connect research support, regulatory requirements, evidence generation, monitoring and institutional responsibilities as an intervention develops. For mCDR, this function is necessarily stage-sensitive: research grants can legitimately support activities whose climate effectiveness or environmental consequences remain uncertain, because their purpose may be precisely to reduce those uncertainties; the same uncertainty, however, may make larger-scale deployment inappropriate. Conversely, regulatory requirements designed for commercial activity may be disproportionate for carefully controlled research if they effectively prevent the generation of evidence required for later governance decisions. The governance task is therefore not to maximise either promotion or precaution independently, but to connect them through an adaptive sequence in which the type of support, evidentiary burden, environmental safeguards and institutional oversight evolve with the

maturity, scale and risk profile of the intervention (National Academies of Sciences, Engineering, and Medicine, 2020; Healey et al., 2024; Brun et al., 2026). An effective governance system should enable learning without presuming progression, with alignment therefore becoming the mechanism through which research, regulation and learning are connected across stages, and through which progression can remain conditional, evidence-based and reversible.

Finally, **the absence of meaningful stakeholder participation** poses a systemic barrier. Communities most affected by mCDR, including coastal populations and small island developing states, are often excluded from decision-making processes. This undermines legitimacy and risks reproducing inequities in global climate governance. Broader civil society engagement, local-specific knowledge, and South–South cooperation are rarely integrated into mCDR governance discussions, despite their relevance for ensuring equitable and context-sensitive approaches. Addressing these participation deficits is essential for building trust, aligning mCDR with climate justice principles, and avoiding backlash. Taken together, these cross-cutting barriers highlight that the challenge is not only technical or legal but also political, ethical, and institutional. Without tackling these systemic constraints, the pathway from experimental research to legitimate, large-scale deployment of mCDR will remain blocked.

4 Dimensions within the mCDR governance framework

The preceding analysis shows that the principal challenge for mCDR governance is not the complete absence of relevant rules or institutions, but their fragmentation across legal regimes, policy domains, institutions and stages of technological development. Existing arrangements provide important elements of governance (including environmental authorisation, scientific assessment, monitoring, stakeholder participation, research support and marine planning), but these elements do not yet operate as an integrated system capable of consistently guiding decisions under conditions of uncertainty.

Against this background, this chapter identifies the core building blocks of a multi-dimensional governance framework for mCDR. The five dimensions were not adopted directly from a single existing framework. Rather, they were developed iteratively through the synthesis of three complementary sources of evidence: (i) the legal, ethical and geopolitical analysis undertaken in D5.1 and the governance gaps identified in Chapter 3; (ii) relevant mCDR governance and assessment literature, together with scientific, societal and economic evidence generated across SEAO2-CDR; and (iii) expert and stakeholder engagement undertaken through the WP5 CPr. Across these sources, a set of recurring governance questions emerged concerning legal permissibility and accountability; ethical acceptability and justice; the adequacy of scientific evidence and treatment of uncertainty; the design of economic support and allocation of financial risk; and the distribution of institutional responsibilities and coordination across governance levels (Table 3). These recurring functions provide the analytical basis for the five dimensions used here.

The stakeholder-engagement process also helped to refine this analytical structure. Consultations and deliberative workshops were organised around closely related questions - including legal feasibility, permitting and authorisation, ethical and justice concerns, environmental risk, MRV, stakeholder inclusion, institutional responsibility and the conditions for responsible piloting or possible progression. The engagement was therefore not used to derive the dimensions independently from the literature, but to bring the analytical framework into dialogue with practical experience, identify areas of overlap and tension, and assess whether the proposed building blocks captured the governance concerns encountered by actors working across research, policy, regulation, civil society and potential implementation contexts.

The resulting structure is consistent with, but not identical to, existing frameworks because these serve somewhat different analytical purposes. Baatz et al. (2025), for example, provide an assessment framework for judging the feasibility and desirability of individual mCDR options. They distinguish techno-environmental, political and legal feasibility from effectiveness, economic efficiency, justice and environmental ethics, and separate descriptive information from normative evaluation. This distinction is particularly useful for the present framework because it demonstrates why legal or technological feasibility cannot substitute for ethical justification, social legitimacy or broader assessment of consequences. Doney et al. (2025) connect scientific and technological readiness with legal safeguards and government responsibilities for research support, participation, monitoring and responsible development, thereby linking evidence generation and regulation with economic support and institutional capacity. The National Academies of Sciences, Engineering, and Medicine (2026) emphasise how governance requirements vary according to actor configurations, distributions of power and the transition from research towards possible deployment, drawing attention to accountability, institutional responsibility and adaptive oversight. The five dimensions adopted here represent the synthesis of these

concerns into governance functions suited to the objective of this deliverable, rather than an alternative assessment taxonomy.

Five interdependent dimensions are considered (Table 3): (1) legal and regulatory arrangements; (2) ethical and social acceptability; (3) scientific knowledge, monitoring and uncertainty; (4) support instruments, economic incentives and risk-sharing mechanisms; and (5) institutional and multi-level governance. These dimensions **are analytically distinct but operationally interdependent, and none should be understood as hierarchically prior to the others**. Rather, each performs a different governance function while interacting with the remaining dimensions.

The legal and regulatory dimension establishes the conditions of legal permissibility, procedural safeguards and enforceable accountability. The ethical and social dimension addresses questions of normative desirability, justice and social legitimacy that cannot be resolved through legal compliance alone. The scientific dimension provides the evidentiary basis for decision-making and establishes how uncertainty, monitoring and changing knowledge should inform governance decisions. The economic dimension concerns the design and sequencing of support instruments and incentives, as well as the allocation of financial and investment risks. Finally, the institutional and multi-level governance dimension addresses how competences and responsibilities are distributed, which actors perform the relevant governance functions, and how coordination takes place across institutions and territorial levels.

These distinctions do not imply that the dimensions operate independently. On the contrary, many governance questions arise precisely at their interfaces. Legal authorisation depends on an adequate scientific basis; scientific evidence must be translated into regulatory and institutional decisions; economic support should be aligned with scientific and regulatory readiness; and the legitimacy of governance decisions depends on both procedural safeguards and meaningful opportunities for affected stakeholders to participate. The framework therefore focuses not only on the individual dimensions but also on the mechanisms through which they interact.

Dimension	Core governance question
Legal and regulatory	**May** the activity proceed, and under what enforceable conditions?
Ethical and social acceptability	**Should** it proceed, and under what conditions would it be legitimate and just?
Scientific knowledge, monitoring and uncertainty	**What evidence is sufficient** to support the decision, and how is uncertainty managed?
Support instruments, economic incentives and risk-sharing mechanisms	**How should development be supported and risks allocated** without incentivising premature deployment?
Institutional and multi-level governance	**Who decides, coordinates, monitors and enforces**, and at what governance level?

Table 3. Core dimensions and interdependencies of the multi-dimensional mCDR governance framework

The chapter provides an analysis of each building block, addressing its functional role, theoretical justification and interdependencies with other elements of the framework. The separation of the dimensions is therefore primarily analytical: in practice, responsible mCDR governance depends on their coordinated application.

4.1 Legal and regulatory dimension

The legal and regulatory dimension establishes the conditions under which mCDR activities may lawfully proceed and the procedural safeguards and accountability requirements that accompany them. Its function within the multi-dimensional framework is not simply to determine whether individual legal rules apply, but to translate a layered and partly fragmented legal landscape into a workable pathway for particular interventions.

As demonstrated in D5.1, mCDR does not operate in a legal vacuum. Relevant requirements already arise under international, regional, EU and national frameworks: UNCLOS establishes the general marine-environmental baseline; the LC/LP more specialised rules concerning dumping, placement and marine geoengineering; the CBD has developed precautionary guidance relevant to biodiversity impacts; regional seas conventions add geographically specific requirements; and, within the EU, these international obligations interact with environmental legislation, marine planning rules and the emerging carbon-removal certification framework. At the same time, mCDR cannot be treated as a legally unitary activity. Different technique families engage different regulatory gateways and procedural requirements, while the applicable level of scrutiny may increase with scale, footprint, duration, uncertainty and transboundary reach. D5.1 identified legal characterisation, procedural safeguards and accountability as recurring questions across mCDR techniques and conceptualises scale-up through gateway, due-diligence and institutional-capacity thresholds. The governance challenge is therefore one of regulatory integration and differentiation: applicable requirements need to be connected without assuming that a single regulatory pathway is appropriate for all mCDR activities.

Within this context the legal and regulatory dimension can be operationalised through four connected functions:

4.1.1 Legal characterisation and regulatory gateway

A proposed activity should be preliminarily characterised according to its substantive purpose, technical configuration and location, for example as *marine scientific research, dumping or placement of matter, discharge, marine geoengineering* where the relevant LC/LP framework is engaged, aquaculture or cultivation, ecosystem restoration, or transport and geological storage of CO_2. This classification identifies the primary regulatory gateway, competent authority and baseline procedural requirements. It should remain open to reassessment where the design, purpose or scale of the intervention changes. In particular, designation as "research" should not in itself exempt an activity from environmental safeguards or other applicable legal requirements. LC/LP practice concerning ocean fertilisation provides an important precedent in this respect by requiring substantive assessment of whether an activity qualifies as legitimate scientific research rather than relying solely on the description adopted by the project proponent. Where more than one legal characterisation is plausible, the relevant regimes should be interpreted and applied together so that one category is not used to circumvent requirements arising under another. The purpose of the classification gateway is therefore not simply to attach a legal label to the intervention, but to establish the regulatory pathway through which subsequent assessment, monitoring and accountability requirements will be determined.

4.1.2 Stage-, scale- and risk-sensitive authorisation and accountability

Building on D5.1, this step distinguishes between three forms of regulatory threshold: a gateway threshold, at which the nature or scale of an activity activates additional legal regimes or procedural requirements; a *due-diligence intensity threshold*, at which increasing foreseeability and magnitude of potential harm require more demanding assessment and precaution; and an institutional-capacity threshold, at which the complexity, transboundary reach or involvement of private operators requires the authorising State to demonstrate adequate supervisory and enforcement capacity. Regulatory requirements should therefore not remain static as an intervention moves from controlled research towards larger field experimentation or possible deployment. In practical terms, authorisation should operate as a conditional and reviewable process rather than as a one-off permission. Requirements should evolve with the maturity, scale, spatial footprint, duration, uncertainty and potential environmental effects of the activity. Depending on the relevant stage and technique, these may include technique-specific and cumulative environmental impact assessment, baseline-data requirements, monitoring and disclosure obligations, independent scientific assessment, spatial or temporal limits and predefined review or stop triggers. Where the scale or risk profile changes materially, renewed assessment should be required rather than assuming that an earlier research authorisation remains sufficient.

The same pathway should clarify accountability across the lifecycle of the intervention. Authorisations should specify who is responsible for compliance, monitoring, reporting, remediation and data retention, as well as who has authority to require modification, suspension or termination when relevant conditions are no longer met. Where environmental effects or claimed carbon storage extend beyond the active project period, the regulatory pathway should also address continuing monitoring and, where appropriate, financial-security or post-closure obligations. The purpose is to ensure that adaptive regulation does not result in adaptive responsibility: flexibility in regulatory conditions must be accompanied by clear allocation of responsibility and enforceable oversight.

4.1.3 Cumulative compliance, cooperation and non-dilution

For activities within the scope of the BBNJ Agreement, for example, its screening and environmental-impact-assessment procedures should operate alongside relevant UNCLOS, LC/LP and other applicable requirements rather than replacing them. Similarly, regional seas regimes may impose more specific conditions within their geographical scope. Under OSPAR, Decision 2007/1 prohibits the storage of CO_2 streams in the water column or on the seabed, whereas Decision 2007/2 establishes conditions for storage in sub-soil geological formations. The building block, therefore, proposes a non-dilution principle: where a more specific or geographically applicable regime introduces additional protective requirements, reliance on a more general regulatory route should not weaken those conditions.

This interface also incorporates **cooperation triggers.** Where an activity has plausible transboundary effects, increasing scale, dispersal potential or uncertainty should trigger corresponding requirements for notification, information-sharing, consultation and, where appropriate, coordinated monitoring. Cooperation is therefore linked to the characteristics of the intervention rather than treated as a uniform requirement applied equally to all stages.

At the national level, cumulative compliance could be supported through a **coordinated or single-window administrative mechanism**. This would not necessarily require a single new mCDR statute or the transfer of all regulatory powers to one authority. Instead, a designated lead process could identify the relevant permits, authorities and procedural requirements, establish their sequencing, and provide a common administrative entry point while preserving the substantive competences of individual regulators. Common project dossiers and interoperable repositories for EIA documentation, monitoring plans, consultation records and monitoring outcomes could further support coordination and reduce the risk that separate authorities assess different components of the same intervention in isolation.

4.1.4 Linking environmental legality and carbon accounting

Finally, environmental legality is connected **to carbon accounting through a lawful-provenance and data-interoperability bridge**. Marine environmental authorisation and carbon-removal certification perform distinct governance functions and should remain separate. Certification cannot substitute for environmental authorisation, while environmental authorisation does not itself establish a valid carbon-removal claim. This distinction is increasingly relevant as carbon-removal accounting and certification frameworks develop alongside marine environmental regulation. Any future certification or publicly recognised carbon-removal claim associated with mCDR should be supported by evidence that the underlying activity was lawfully authorised and remained compliant with the relevant environmental conditions. In parallel, monitoring and MRV systems should be interoperable where technically and legally appropriate, so that data concerning project baselines, environmental effects and carbon-removal performance can inform the different regulatory processes without conflating their purposes. Such a lawful-provenance requirement would help prevent an “accounting without authorisation” pathway in which a removal claim acquires economic or policy value independently of the legality and environmental performance of the underlying marine intervention.

The same interface should operate in the opposite direction. Monitoring undertaken for carbon quantification should, where relevant, feed back into regulatory oversight and subsequent environmental decision-making. Evidence generated through controlled experimentation can thereby inform decisions on continuation, modification or possible progression, while environmental monitoring can provide

information necessary to test the integrity of removal claims. This creates a regulatory feedback loop in which authorisation generates conditions for evidence production, and evidence production informs subsequent authorisation.

Taken together, the proposed legal and regulatory dimension establishes a sequence of classification that can provide an interface through which existing and emerging rules can operate as an integrated and adaptive decision pathway (Figure 2). This responds directly to the conclusions of D5.1, which identify legal characterisation and regulatory gateways, procedural safeguards, accountability, monitoring, cooperation and institutional capacity as interconnected requirements and call for their translation into operational governance tools. Through this framework, legal authorisation enables controlled research and learning where justified but does not create a presumption of subsequent scale-up. Continuation, modification, suspension, termination or consideration of progression remain possible outcomes depending on the evidence generated and the capacity of the governance system to satisfy the requirements applicable at the next stage.

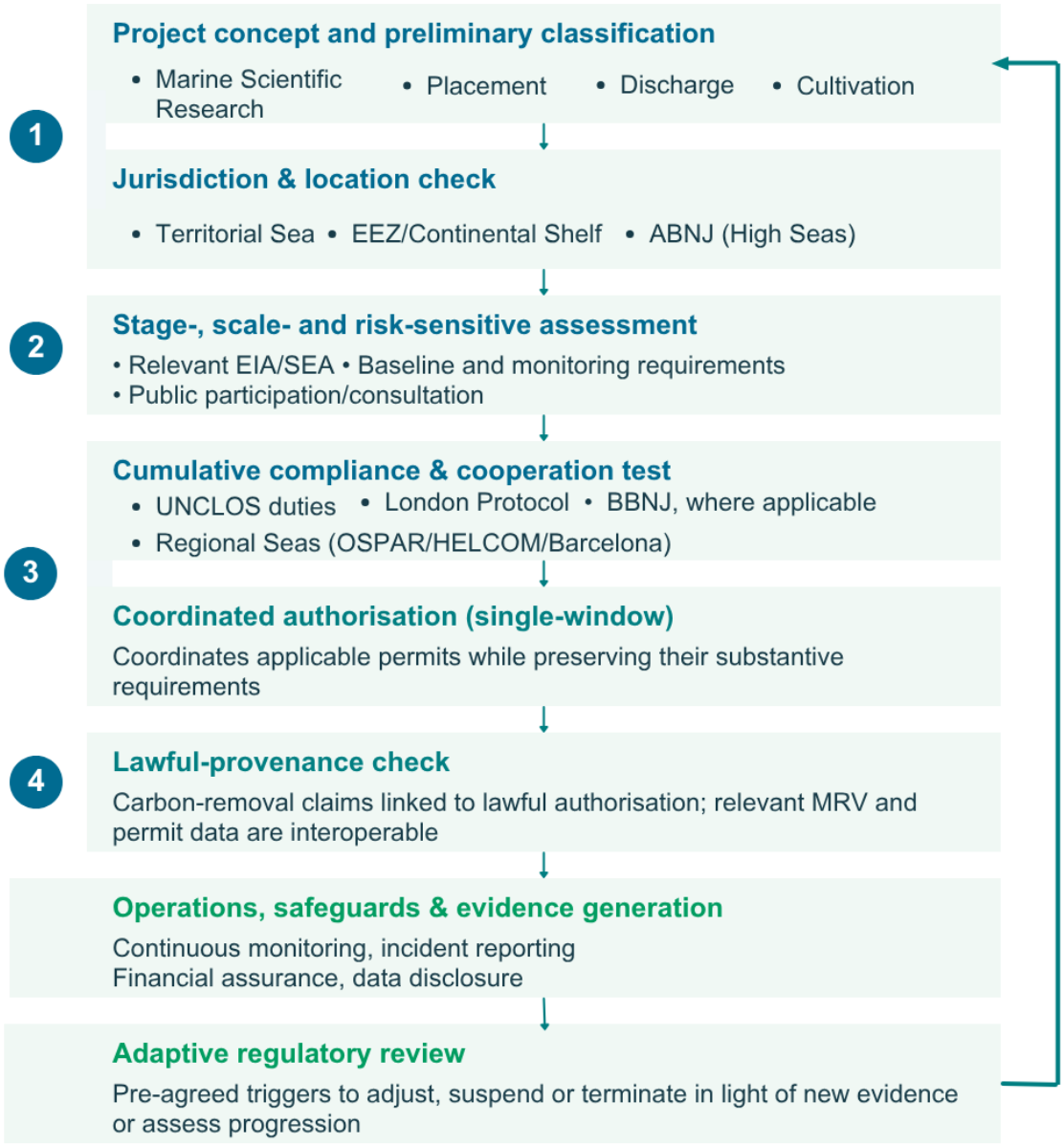

Figure 2. Proposed legal regulatory pathway

4.2 Ethical and social acceptability

Ethical considerations and social acceptability constitute a second core component of the multi-dimensional mCDR governance framework. As shown in D5.1, ethical questions cannot be treated as uniform across mCDR approaches or across stages of development. The nature and intensity of ethical concerns may vary according to the type of intervention, its scale and location, the communities and ecosystems affected, and whether the activity concerns research, experimentation or possible deployment. In particular, questions of moral hazard and mitigation deterrence, technological and

political lock-in, substantive and procedural justice, intergenerational justice, accountability, transparency and institutional legitimacy are recurring concerns for mCDR governance. These issues are closely connected to social acceptability: an intervention may be technically and legally feasible while remaining socially contested or normatively difficult to justify. This dimension therefore treats ethical and social considerations not as an assessment added after technical or regulatory decisions have been made, but as conditions that inform whether, and under what terms, an intervention should proceed.

4.2.1 Social acceptability and public perceptions

The feasibility of mCDR projects rests on the desirability and social acceptability of such (not solely) geoengineering technologies.[35] Public support tends to be higher for the technologies that are perceived as more natural, such as blue carbon management, compared to ocean iron fertilisation, alkalinity enhancement, and artificial upwelling (Fuss et al., 2014; Rickels et al., 2019). Thus, societal opposition is a major constraint to feasibility to some mCDR approaches. Findings from WP4 (namely D4.2 based on an online survey of 16,739 respondents across eight countries) stress that awareness of OAE remains very low, while attitudes vary substantially across countries,[36] deployment configurations and the way the purpose of the intervention is presented. Responses were often characterised by uncertainty rather than categorical support or opposition. Coastal OAE was perceived more favourably when linked to familiar coastal-management practices, while responses were less favourable in some contexts when associated with industrial infrastructure. Framing OAE in relation to ocean acidification and ecosystem protection also generated more positive responses than framing it primarily as a climate-mitigation measure. These results should not be interpreted as evidence that communication can be used to manufacture acceptance. Rather, they show that perceptions are context-dependent and still being formed, and that early project design, institutional arrangements, communication and local experience may influence how mCDR is understood.

Deliberative and negotiated-rulemaking exercises (Task 4.3) support these findings, as stakeholders assessed mCDR not only in terms of carbon-removal potential, but also through ecological uncertainty, local livelihoods, regulatory responsibility, transparency, MRV, commercial interests, research-commercialisation boundaries and the distribution of risks and benefits. Despite differences in emphasis, several areas of convergence emerged: mCDR should remain complementary to emissions reductions; pilots require clear responsibility and monitoring arrangements; environmental and carbon-removal data should enable independent scrutiny; and affected local and sectoral stakeholders should be involved. At the same time, tensions remained around speed versus precaution, transparency versus commercial confidentiality, research versus premature commercialisation, the role of carbon markets, and expert assessment versus wider participation. These findings suggest that stakeholder engagement should not be expected to produce consensus. Rather, the proposed framework should provide procedures through which differing values, interests and interpretations of uncertainty can be expressed and taken into account in decisions on continuation, modification or progression.

[35] As other projects have demonstrated, see for example: Holland-Cunz, A., & Baatz, C. (2026). How to govern carbon dioxide removal: An assessment framework for policy instruments. *Climate Policy, 26*(6), 856–871. https://doi.org/10.1080/14693062.2025.2459315; Kreuzburg, M., Baatz, C., Bednarz, L., Böttcher, M., Merk, C., Morganti, T., Tank, L., Yao, W. B., Wehnert, H., & Rehder, G. (2024). *Unified ASsessment framework for proposed methods of MArine CDR and interim knowledge SYnthesiS (ASMASYS)*. ASMASYS. https://doi.org/10.3289/CDRmare.37; Tank, L., Voget-Kleschin, L., Garschagen, M., Boettcher, M., Mengis, N., Holland-Cunz, A., Rehder, G., & Baatz, C. (2025). Distinguish between feasibility and desirability when assessing climate response options. *npj Climate Action, 4*, 34. https://doi.org/10.1038/s44168-025-00237-2.

[36] See D.4.2 for more information.

4.2.2 Justice, fairness and the distribution of burdens and benefits

Considerations of both substantive and procedural justice should also be a part of the multi-dimensional framework. While substantive justice addresses the questions of fairness in the distribution of burdens and benefits, procedural justice addresses the fairness of processes of decision-making. Although not always, the distribution of burdens and benefits is often an outcome of procedural justice. Moreover, the distribution of burdens and benefits of mCDR will also apply across time and, therefore, raises questions of how to account for the interests of future generations in decision-making.

The distribution of burdens and benefits at the local level should address socioeconomic and cultural nuances of communities potentially impacted by the mCDR projects. This will be specific in each case, so the multi-dimensional framework cannot have one standard to follow to achieve substantive justice. For instance, an iron fertilisation project in some areas might be opposed by the coastal communities, while in other instances it might be supported by the local communities with hopes to benefit from the financial gains from carbon credit sales as well as replenishing depleted fish stocks (Gannon & Hulme, 2018).[37] The burdens on local communities that might depend on the integrity of ecosystems can be substantial, while the benefits are often described at planetary terms (Assmy et al.,2006). Moreover, in many instances, the impacted coastal communities will include Indigenous communities, so it is important not to replicate the patterns of ecological imperialism and domination. Hence, procedural justice requires inclusive participation of the affected communities in the decision-making processes around research, development and deployment of mCDR technologies. The multi-dimensional framework should account for partnering with and accounting for the livelihoods of the communities that will be impacted by the projects grounded in the All-Affected Principle discussed in D5.1. This requires focusing mCDR governance on the local level to ensure that adequate platforms for deliberation and participation in decision-making exist, e.g., townhalls, workshops, and surveys.

As noted in D5.1, mCDR may transfer both benefits and burdens to future generations, including through long-term environmental effects, monitoring and remediation obligations, or technological and institutional lock-in. At the same time, non-use of potentially effective mCDR approaches may also impose future burdens through unabated climate change, meaning that intergenerational justice cannot be reduced to avoiding all present-day intervention. The governance framework should therefore require explicit consideration of how risks, benefits and responsibilities are distributed over time, including the duration of expected carbon storage, long-term environmental uncertainties and continuing stewardship obligations as future generations cannot participate directly in current decisions.

Scaled up to the international and global level, mCDR projects will face similar problems of substantive and procedural justice, but the nature of fragmented global governance and the power asymmetries among nation-states make these challenges even more complex. For mCDR projects that take place in the ABNJs or across borders, the multi-dimensional framework should focus on ways to establish inter-state benefit sharing to compensate states that are geographically disadvantaged or lack technological and financial capacity to engage in mCDR (the BBNJ Agreement offers some potential in this regard). Benefit-sharing from the projects in the high seas is supported by the principle of equity, operationalised through the principle of Common But Differentiated Responsibilities and Respective Capabilities (CBDRRC) under PA in international law and the recognition of the differentiated positions of developing states, as well as

[37] As the example of the Haida Salmon Restoration Corporation's ocean fertilisation experiment illustrated, mCDR can be supported by some within a community and yet, might draw an external criticism and opposition.

landlocked and geographically disadvantaged countries under the law of the sea. Interstate benefit-sharing from the mCDR activities in the high seas can also be justified when these activities diminish the opportunities for other states and when they require a high level of technological capacity (Craik, 2025). Additionally, considering that over 45% of EEZs are in developing nations with settings potentially ideal for mCDR deployment, but the projects are likely to be developed and funded by developed states, technological and financial requirements may favour development in countries with greater access to expertise and capital (Doney et al., 2025). Considering the history of the developed nations dominating climate negotiations and governance, it is especially important to establish an appropriate international institutional platform for inclusive deliberation and decision-making. In the short term, inclusive international communities of practice (see Recommendation 8 in section 6.3) can prepare the ground for such a platform by building shared practices and trust, but they cannot substitute for formal and accountable decision-making within existing institutions such as the LC/LP and the BBNJ Conference of the Parties.

In sum, at both domestic and international levels, the ethical and social dimension requires attention to substantive and procedural justice. Substantive justice concerns the fair distribution of risks, burdens and benefits associated with mCDR, while procedural justice requires inclusive decision-making that allows potentially affected actors to participate meaningfully in the governance of research and potential deployment. Within the multi-dimensional framework, these considerations therefore require attention to public perceptions and social acceptability, the distributional consequences of mCDR interventions, and the inclusiveness and legitimacy of decision-making processes.

The ethical and social dimension complements other components of the framework by addressing questions that cannot be resolved through legal compliance, scientific evidence or institutional capacity alone. While the legal dimension establishes conditions of legal permissibility and procedural safeguards, ethical and social considerations address broader questions of justice, legitimacy, acceptability and fairness in the distribution of risks and benefits. They also interact with the scientific, economic and institutional dimensions, particularly where uncertainty, the allocation of costs and benefits, or differences in power and capacity shape the legitimacy of governance decisions. The principles identified here also provide the normative basis for the stakeholder-centred approach developed in Chapter 5, which focuses on their practical operationalisation through stakeholder identification, inclusion, participation and co-creation.

4.3 Scientific knowledge, monitoring and uncertainty

Scientific knowledge, monitoring and uncertainty are pivotal issues in the governance of mCDR, where the limits of current ocean science intersect with contested political and ethical debates. Their role within the multi-dimensional framework is to establish **what evidence is required to inform decisions on mCDR research, experimentation and possible progression, how this evidence should be generated and assessed, and how remaining uncertainty should be incorporated into governance decisions**. Despite significant advances in marine biogeochemistry and climate modelling, existing knowledge remains insufficient to predict the large-scale impacts of mCDR techniques on ecosystems, biodiversity and global carbon cycles. These uncertainties have direct governance implications: mCDR authorisation and removal claims need to be supported by best available science and adequate monitoring, while uncertainty becomes increasingly relevant as the scale, footprint and potential consequences of an intervention increase (National Academies of Sciences, Engineering and Medicine, 2022; Johnson et al., 2024; Brun et al., 2026).

This understanding builds on the broader assessment logic developed within the project. Rather than treating readiness simply as a question of whether a technology can technically be operated, the framework adopts a **whole-system understanding of readiness, taking into account both the maturity of the underlying technology and its capacity to perform the intended carbon-removal function**.[38] For example; D2.1 applies this logic by considering the technology together with carbon-removal performance, recognising that individual technical components may already be relatively mature while considerable uncertainty remains regarding the efficacy and durability of carbon removal, the ability to monitor and verify it, and the environmental implications of larger-scale operation. D2.3 complements this perspective by highlighting the high level of uncertainty associated with prospective environmental assessments of emerging mCDR approaches, as well as current methodological limitations in comprehensively capturing impacts on the marine environment.[39]

4.3.1 Evidence requirements and scientific readiness

Evidence requirements should be technique-, stage- and context-specific. Before an intervention proceeds, the relevant evidence needs should be defined, including appropriate environmental and carbon baselines, expected removal pathways and durability, potential ecosystem effects, spatial and temporal boundaries and, where relevant, transboundary dispersal. The level of evidence required should increase as an activity moves from controlled research towards larger or longer-duration experimentation. Progression should therefore depend on evidence appropriate to the next stage rather than on a general expectation that accumulated research will eventually justify scale-up.

This stage-sensitive approach reflects the whole-system understanding of readiness outlined above. An mCDR intervention may, for example, be sufficiently mature for controlled research while the evidence concerning carbon-removal performance, durability, environmental effects or MRV remains insufficient to justify larger-scale experimentation or potential deployment. Conversely, uncertainty in one dimension should not automatically preclude research where the activity can be conducted under conditions appropriate to its stage and risk profile. Scientific readiness should therefore be understood as decision-specific and progressive, with the evidentiary threshold increasing as the scale, duration and potential consequences of an intervention increase.

4.3.2 Environmental monitoring and carbon-removal MRV

Environmental monitoring and carbon-removal MRV should remain distinct but interoperable. Carbon MRV must establish whether the extent of CO_2 removal from the atmosphere as a consequence of the intervention is measurable, reportable and verifiable, while environmental monitoring addresses broader effects on marine ecosystems and other environmental conditions. MRV and transparency provide a critical link between the legality, legitimacy and the credibility of removal claims (Brun, et al., 2026; Doney et al., 2025).

The framework should therefore require monitoring plans capable of supporting both functions, with appropriate baselines, transparent methods, data retention and independent scrutiny, while avoiding the assumption that evidence sufficient to verify carbon removal is necessarily sufficient to demonstrate environmental acceptability.

[38] See D2.1 for more information

[39] See D2.3 for more information

This distinction is particularly important given the uncertainties identified across the scientific and technical assessment of mCDR approaches. Challenges relating to storage durability and reliable MRV recur across multiple approaches, while the environmental effects of larger-scale interventions remain difficult to predict. Environmental assessment should therefore extend beyond carbon performance alone. Where relevant effects cannot yet be quantified reliably, they should remain visible as uncertainties and, where appropriate, be considered qualitatively rather than being treated as absent.

Although environmental monitoring and carbon-removal MRV may rely on overlapping datasets, models or monitoring infrastructure, they answer different governance questions. Carbon MRV concerns the credibility and durability of the claimed removal outcome, whereas environmental monitoring concerns the wider effects of the intervention on marine ecosystems and environmental conditions. Interoperability should facilitate the use of evidence across governance processes without conflating carbon-removal performance with environmental acceptability.

4.3.3 Uncertainty and adaptive review

Uncertainty should be connected to predefined review and decision thresholds. Scientific uncertainty should not automatically prevent research, but neither should the absence of demonstrated harm be interpreted as evidence of safety. Where potential harm is serious or difficult to reverse, uncertainty strengthens the relevance of precaution and the need for monitoring and adaptive conditions. Monitoring should therefore feed directly into adaptive review through predefined triggers for continuing, modifying, pausing or terminating an activity and, where justified, considering progression (Johnson et al., 2024).

This establishes a **feedback loop** in which authorisation determines evidence requirements, evidence generation informs review, and review determines whether the conditions for the next stage are satisfied.

The objective is not to require the elimination of uncertainty before an activity can proceed. For emerging mCDR approaches, uncertainty is unavoidable and research may itself be undertaken to reduce it. The governance task is instead to ensure that uncertainty is explicitly identified, characterised and communicated, and that it is reflected in the conditions attached to decisions. This includes uncertainty arising from limited data, modelling assumptions, methodological choices, future technological configurations and environmental variability**. Sensitivity and scenario analyses can provide useful inputs into governance by indicating where findings are relatively robust, where they remain contingent on particular assumptions and where additional evidence is required before progression can be considered**.

4.3.4 Knowledge production, transparency and scientific capacity

Scientific capacity is unevenly distributed, while the actors that develop monitoring methodologies and verification standards may acquire considerable influence over which evidence becomes authoritative. The framework should therefore promote transparent methodologies, accessible monitoring results, independent review and cooperation across scientific and regulatory communities.

Transparency is especially important in the context of emerging technologies, where evidence may depend on projected technological configurations, modelling choices or commercially sensitive information. The project's work on prospective assessment identifies transparency, completeness and reproducibility as recurring challenges and highlights the importance of reporting data, assumptions,

methodological choices and limitations as comprehensively as possible. For governance purposes, transparency should therefore concern not only final results but also the processes and assumptions through which those results are generated.

These scientific and technical uncertainties create a fertile space for the emergence of **CPr, which can be defined as groups bound together by a shared practice and background knowledge developed through sustained interaction** (Wenger, 1998; Adler, 2008; Bicchi, 2022). There are already existing international collaborations that are examples of such practice-based cooperation in mCDR, e.g. GESAMP Working Group 41[40] that brings together experts to assess the environmental and societal implications of ocean interventions for climate change mitigation, or the international community behind the Guide to Best Practices in Ocean Alkalinity Enhancement Research, which provides a concrete example of developing shared guidance across scientific, monitoring, legal and social questions (Oschlies et al., 2023). Such collaborations can support learning across disciplines and jurisdictions. However, their contribution to equitable governance depends on whose knowledge is represented and whether less-resourced institutions and affected communities can participate meaningfully. This links the scientific dimension to the capacity-building and inclusive cooperation proposed in Recommendation 8 of Section 6.3**.**

While the concept of CPr can overlap with epistemic communities, CPr emphasise learning through shared activities, whereas epistemic communities are characterised by shared causal and normative beliefs, standards of valid knowledge and a common policy enterprise (Haas, 1992). For mCDR governance, this distinction draws attention to the importance of developing and exchanging practical experience with MRV protocols, monitoring routines and permitting procedures alongside scientific expertise.

Taken together, the scientific dimension establishes the evidentiary conditions through which mCDR activities can be assessed, monitored and reviewed as they develop. A whole-system understanding of readiness means that technological maturity alone is insufficient: **governance decisions should also consider the robustness of evidence concerning carbon-removal performance and durability, environmental consequences, monitoring and verification, and the uncertainties associated with each of these elements**. Scientific readiness should therefore be assessed in relation to the specific decision being taken and the stage, scale and context of the intervention. In practical terms, this connection requires an exchange between those generating evidence and those responsible for assessing and supervising an activity. Decision-makers should identify the questions that need to be answered for the proposed stage, scale and location; scientific assessments should clarify what can be established, with what confidence and subject to which limitations; and these findings should inform monitoring obligations and review triggers. Where important gaps remain, they should guide further research or changes to the proposed activity.

4.4 Support instruments, economic incentives and risk-sharing mechanisms

Support instruments, economic incentives and risk-sharing mechanisms constitute the economic dimension of the multi-dimensional governance framework. Their role is **to address barriers to research, innovation and potential deployment while ensuring that financial incentives evolve in line with the**

[40] https://www.gesamp.org/work/groups/41

scientific, regulatory and institutional maturity of mCDR approaches. Economic viability should therefore not be treated as an independent indicator of readiness, but as one element of the wider conditions under which an intervention may progress.

For mCDR to progress from research towards potential commercial application (for private agents to invest in these technologies), there must be a profitable business case. That is not the case, as is usual with emerging technologies, which may not yet be in a commercial phase, or may not be deployed at a scale that allows cost reductions due to learning by doing and economies of scale. However, that results in a vicious cycle: insufficient investment may limit learning-by-doing and delay cost reductions. To break this cycle, support instruments are typically required to bring these technologies closer to the market and to make them attractive to investors (Blanco et al., 2022; Armitage et al., 2024; OECD, 2024).

This need is particularly relevant given the current maturity and economic uncertainty of many mCDR approaches. The project's technical assessment shows that costs vary substantially across approaches and case studies and that important components of the overall economic case, including MRV, form part of the operational costs of mCDR systems. More broadly, the whole-system approach to readiness implies that economic support should be considered alongside carbon-removal performance, environmental impacts and MRV rather than on the basis of technological feasibility alone.

SEAO2-CDR engagement with the emerging mCDR sector indicates that the economic dimension extends beyond individual financial instruments: responsible commercialisation depends on a wider enabling ecosystem in which financing, market development, MRV and standards, permitting, policy frameworks and coordination among developers, investors, buyers, registries and public authorities evolve together.[41] Discussions within the project have identified financing pathways and market formation as closely connected to regulatory uncertainty, MRV development, permitting and responsible deployment, rather than as separate commercial challenges.

4.4.1 Technology support and demand-side incentives

The rationale for dedicated technology support is distinct from the climate value of the carbon removal itself: while carbon pricing or other demand-side mechanisms can reward verified climate benefits, technology-support policies address innovation-related market failures, including knowledge spillovers, financing constraints and coordination failures (Armitage et al., 2024). Therefore, two types of economic incentives may be needed for mCDR: first, a **meaningful carbon price that may internalise the benefits that these technologies provide in terms of carbon removal**; and second, a **technology support policy that will help them become marketable.**

Renewable energy technologies are probably the best-known case in which these two policies have been used. Besides being able to benefit from carbon prices (that disincentivise carbon-emitting technologies), different policies such as investment subsidies, feed-in tariffs, green certificates, or auctions have helped renewables run their learning curve to a point in which they are competitive with fossil fuels. Carbon capture and carbon-removal technologies have similarly benefited from combinations of public R&D support, grants, tax incentives and other mechanisms designed to reduce investment and technology risks (Blanco et al., 2022; OECD, 2024; International Energy Agency, 2020).

[41] See D6.1. for more information

For mCDR, however, the appropriate balance between technology-push and demand-side instruments depends strongly on the stage of development. Carbon-credit revenues may provide an additional demand-side incentive for some mCDR approaches, but access to crediting remains technique- and methodology-specific rather than generally available. Crediting depends on the ability to demonstrate additional, measurable and sufficiently durable carbon removal and to address uncertainties related to leakage, reversal and other integrity concerns. At the same time, carbon credits should be distinguished from technology-support instruments: while credits remunerate verified removal outcomes, technology-push policies such as R&D programmes and publicly funded pilot projects support knowledge generation and technological development at earlier stages (NASEM, 2022).

At present, there are relatively few support programmes specifically directed at mobilising learning by doing or economies of scale for mCDR, while technology-push instruments are more common. This is probably explained partly by the early maturity of many approaches, but also by the multiple spatial and jurisdictional scales involved. In many cases, setting up support systems may require coordination across jurisdictions, including decisions on how the benefits arising from public support (such as cost reductions, knowledge creation, employment and technological capabilities) are distributed among states.

4.4.2 Stage-sensitive support and investment risk

Economic support should consequently be stage-sensitive and aligned with the wider readiness of the mCDR intervention. At early stages, public support may primarily facilitate research, monitoring infrastructure, methodological development and controlled experimentation. As the evidence base develops, risk-sharing instruments may support demonstration and learning-by-doing. Stronger demand-side mechanisms should become relevant only where carbon removal can be credibly quantified and the applicable environmental, legal and governance conditions are sufficiently developed.

This differentiated approach is also reflected in the range of enabling mechanisms emerging across the wider mCDR and durable CDR ecosystem. Project-level engagement[42] has identified examples including research and innovation funding, public-private demonstration partnerships, public venture-capital support, government procurement, carbon-market and compliance frameworks, and enabling permitting and community-engagement arrangements. These mechanisms perform different functions and are therefore likely to be relevant at different stages of technological and market development rather than constituting interchangeable forms of support.

Carbon Contracts for Difference (CCfDs), already used in the context of low-carbon and carbon-capture investments, provide one possible model for reducing investment risk. Under a CCfD, public support can guarantee a predefined level of remuneration relative to a reference carbon price or other benchmark, thereby reducing revenue uncertainty for low-carbon investments.[43] While currently applied primarily to industrial decarbonisation technologies, an adapted mechanism could potentially be considered for verified carbon removals once sufficiently robust MRV and certification methodologies are available. Controlled experimental or sandbox-type arrangements may similarly provide a means of supporting learning-by-doing under predefined regulatory, MRV, liability and public-engagement conditions. Within

[42] See D6.1. for more information.

[43] European Commission. (n.d.). *Competitive bidding*. Climate Action. Retrieved September 16, 2026, from https://climate.ec.europa.eu/areas-action/eu-funding-climate-action/innovation-fund/competitive-bidding_en; International Energy Agency. (2020). *CCUS in clean energy transitions*. https://www.iea.org/reports/ccus-in-clean-energy-transitions.

the framework, their purpose would be to enable bounded experimentation and evidence generation rather than to provide an automatic pathway towards commercial deployment.

The sequencing of support is important because financial incentives can themselves influence technological trajectories. Strong demand-side support introduced before the evidence base and governance conditions are sufficiently mature may create technological or institutional lock-in and generate pressure for continued progression. The design of support instruments should therefore reflect not only investment needs, but also the stage of development and the wider readiness of the intervention.

4.4.3 Linking remuneration to verified carbon removal

A further challenge concerns how carbon removals are quantified and valued across different mCDR approaches. This is particularly relevant for instruments that remunerate carbon-removal outcomes, including carbon credits and potentially CCfDs. The economic value of a removal claim depends on whether the removal can be credibly demonstrated and on characteristics such as its durability, additionality and the risks of leakage, displacement or reversal. These factors should therefore be reflected in MRV methodologies and in the design of economic incentives.

Economic remuneration should consequently be linked to verified rather than assumed carbon removal, with appropriate mechanisms to account for uncertainty and differences in durability (Halloran et al., 2025). This creates a direct interface with the scientific dimension discussed in Section 4.3: MRV provides the evidentiary basis for determining whether and to what extent a carbon-removal outcome can credibly be rewarded, while the economic dimension concerns how that verified outcome is translated into financial incentives.

At the same time, verification of carbon removal should not be treated as equivalent to demonstrating the environmental acceptability of the underlying intervention. Economic incentives linked to carbon performance should therefore remain conditional on the wider environmental, legal and governance requirements identified across the framework.

4.4.4 Financial risk-sharing and responsibility

Economic support also raises the question of how financial risks and costs should be distributed between project developers, public authorities and other actors. Support mechanisms should specify who bears the costs associated with monitoring and verification, underperformance, reversal or loss of stored carbon, environmental damage, remediation and long-term stewardship. **The need for public support at earlier stages should not automatically imply that these risks are transferred to the public sector.** Where appropriate, financial-assurance mechanisms, reserve arrangements or performance-dependent payments can be used to link public and private support to project performance and verified outcomes. This is particularly relevant because monitoring and verification constitute continuing operational requirements, while uncertainty concerning long-term carbon-removal performance may create costs that extend beyond the active project period.

The operation of these mechanisms also depends on a broader market ecosystem. Developers, investors, buyers, registries, standards organisations, marketplaces and public authorities perform different but interconnected functions in financing projects, establishing credible removal claims, creating demand and reducing investment uncertainty. The economic dimension should therefore consider not only the design of individual support instruments, but also the coordination of the wider ecosystem through which those

instruments operate. The project's industry engagement already reflects this increasingly diverse ecosystem, bringing together developers alongside registries, marketplaces, investors, research organisations, policy actors and other supporting organisations.

Taken together, the economic dimension provides mechanisms for supporting research, innovation and, where justified, progression, while linking economic rewards to credible outcomes and determining how financial risks are distributed. Its purpose is not to create an independent pathway towards commercialisation, but to ensure that the type and intensity of economic support correspond to the stage and wider readiness of the intervention

The wider enabling ecosystem identified above also provides an important interface with the institutional and multi-level governance dimension**: the effectiveness of economic instruments depends not only on their design, but also on the actors, coordination mechanisms and institutional capacities through which they are implemented**. Aligning these dimensions is important to ensure that economic support facilitates responsible learning and innovation without creating incentives for premature progression or technological lock-in.

4.5 Institutional and multi-level governance

Institutional arrangements and multi-level governance constitute the organisational component of the multi-dimensional framework. Their role is to establish **who performs the different governance functions, how responsibilities are distributed and coordinated across institutions and levels, and whether the institutional system has sufficient capacity to implement, monitor and adapt governance decisions over time**. Effective governance of mCDR therefore requires attention not only to the formal allocation of competences, but also to the relationships, coordination mechanisms and capacities through which those competences are exercised.

4.5.1 Roles, responsibilities and institutional capacity

Institutional arrangements refer to the formal and informal rules, roles and responsibilities that shape decision-making within and across organisations. These arrangements determine how responsibilities are allocated, how priorities are established, how information is exchanged and how coordination is achieved among different actors. In the context of mCDR, they are particularly important because relevant responsibilities may be dispersed across marine environmental authorities, climate-policy bodies, research institutions, maritime-planning authorities, carbon-accounting systems and economic or innovation-policy actors. D5.1 similarly shows that the existence of a formal permit or competent authority is not sufficient in itself: as activities become more complex, transboundary or commercially driven, the authorising State must also possess genuine supervisory, monitoring and enforcement capacity.

An important governance task is therefore to ensure that the principal functions of authorisation, environmental assessment, scientific review, monitoring, carbon accounting, enforcement and long-term oversight are clearly assigned and connected. Overlapping mandates do not necessarily constitute a governance weakness, provided that responsibilities are sufficiently clear and mechanisms exist for coordination and information exchange. Institutional fragmentation becomes problematic where it creates gaps in responsibility, contradictory requirements, duplicated procedures or uncertainty about which body is responsible for monitoring, enforcement or review.

Institutional capacity is equally important. Formal competence does not necessarily guarantee the ability to assess technically complex evidence, oversee monitoring programmes, respond to changing risk profiles or enforce conditions over potentially long time horizons. The framework should therefore consider whether the institutions involved possess adequate scientific and technical expertise, administrative resources, access to relevant information and monitoring systems, and the capacity to coordinate with other competent bodies.

4.5.2 Coordination across governance levels

Multi-level governance provides a useful perspective for understanding these interactions. Rather than locating authority exclusively at one territorial level, multi-level governance describes the dispersion of decision-making authority upwards, downwards and sideways across different jurisdictions and institutions. Hooghe and Marks (2003) distinguish, in this respect, between relatively stable, general-purpose jurisdictions and more flexible, task-specific governance arrangements. For mCDR, both forms are likely to be relevant: national authorities may retain primary permitting and enforcement responsibilities, while regional seas organisations, international treaty bodies, scientific platforms and transboundary coordination arrangements perform complementary functions. The central governance question is therefore not simply which level should decide, but how responsibilities should be connected where mandates overlap.

Local and subnational actors may also become relevant where interventions affect coastal areas, marine planning, infrastructure, livelihoods or other locally specific interests. Multi-level coordination should therefore facilitate coherence between international obligations, regional arrangements, national regulatory systems and locally specific implementation conditions, while maintaining clear lines of responsibility and accountability.

This need for coordination is reinforced by the wider ecosystem emerging around mCDR. Project engagement has involved not only technology developers, but also registries and standards organisations, investors, marketplaces, research institutions, policy organisations and other actors involved in financing, assessment, market development and governance. Experience from these exchanges also shows that practical challenges such as permitting, MRV, financing, market formation and responsible deployment are closely interconnected rather than belonging to entirely separate institutional domains. Institutional arrangements therefore need to facilitate coordination both across territorial levels and across different functional areas of governance.

4.5.3 Centralisation, decentralisation and polycentric coordination

A key consideration is consequently the interplay between centralisation, decentralisation and polycentric coordination. Centralised arrangements can support common standards, consistency and accountability, whereas decentralised structures may provide greater flexibility and responsiveness to local environmental and institutional conditions. Polycentric governance further highlights the potential value of multiple, partly autonomous centres of decision-making that can experiment, exchange information and learn from one another, provided that mechanisms exist for coordination and mutual adjustment (Ostrom, 2010).

For mCDR, the framework should therefore not prescribe one institutional model, but combine common safeguards and minimum requirements with sufficient flexibility to accommodate differences between techniques, jurisdictions and stages of development.

Functions requiring consistency, such as minimum monitoring, reporting or information requirements, may benefit from common standards, while implementation and oversight arrangements may need to remain responsive to specific environmental, administrative and socioeconomic contexts. At the same time, institutional flexibility should not create regulatory gaps or opportunities to select the least demanding governance pathway. Coordination should therefore be supported by clear allocation of responsibilities, common information requirements and mechanisms for managing cases in which several authorities or governance regimes are simultaneously relevant.

This need for coordination is particularly pronounced because the existing mCDR governance landscape is institutionally fragmented (Section 3). As concluded within D5.1; future mCDR governance will depend increasingly on coordination across international and regional frameworks, the development of common MRV and environmental-assessment standards, and shared scientific platforms. At the same time, differences in technological and institutional capacity may allow early movers to shape emerging standards and regulatory practices, creating additional coordination and equity challenges.

4.5.4 Coordination, stakeholder engagement and conflict resolution

Effective institutional and multi-level governance relies on mechanisms for stakeholder engagement, coordination and conflict resolution. Clear communication channels, formalised consultation processes and collaborative decision-making platforms are essential to align objectives across diverse actors, prevent duplication and resolve potential conflicts. In the mCDR context, these mechanisms are crucial for maintaining legitimacy, enhancing compliance and fostering collaborative problem-solving across institutional boundaries. Strong public oversight is similarly emphasised in recent mCDR governance work, Doney et al. (2025), which call for rigorous public standards, clear permitting pathways, transparent research and robust monitoring arrangements.

Within the present framework, however, stakeholder participation should not be treated as a separate institutional function confined to this dimension. Rather, institutional arrangements should ensure that the participatory requirements identified across the legal and ethical dimensions are embedded in decision-making processes through clear responsibilities for consultation, access to information, consideration of stakeholder input and, where appropriate, independent oversight. The practical mechanisms for stakeholder identification, participation and co-creation are developed further in Chapter 5.

4.5.5 Institutional learning and adaptation

Finally, the institutional framework needs to support learning and adjustment over time. As scientific knowledge develops, monitoring results accumulate and new regulatory or commercial arrangements emerge, institutional responsibilities may need to evolve. Science-policy platforms, shared data systems and regular coordination between regulators, researchers and other competent bodies can help ensure that new evidence is translated into regulatory practice.

Governance arrangements should therefore allow institutional roles and coordination mechanisms to adapt without requiring the overall architecture to be redesigned whenever new evidence or technologies

emerge. The flexible coordination structures developed within the project also illustrate the potential value of forums that enable information exchange across actors operating at different stages of development while leaving more specialised technical or regulatory questions to the relevant competent bodies.

In conclusion, the institutional and multi-level governance component of the mCDR framework provides the structural and procedural foundation necessary for coordinated, coherent and adaptive implementation. By articulating the roles, responsibilities and interactions of actors across governance levels, this dimension highlights the importance of institutional capacity as both an enabler and mediator of multi-dimensional governance. Its role is not to duplicate the legal rules, scientific criteria or economic instruments addressed in the preceding sections, but to ensure that the actors responsible for applying them have clear mandates, sufficient capacity and effective mechanisms for coordination across institutional and territorial boundaries.

5 Stakeholder-centred design and participation

Decisions concerning whether and under what conditions mCDR research, piloting or potential deployment might proceed affect a wide range of actors with different interests, forms of knowledge, capacities, rights and exposure to potential risks and benefits. These include public authorities at different governance levels, scientific institutions, technology developers, carbon-market actors, environmental organisations, fisheries and aquaculture, maritime industries, coastal communities, Indigenous Peoples and the wider public. Stakeholder participation therefore constitutes an integral component of legitimate and effective mCDR governance rather than a supplementary communication activity.

The term "stakeholder" requires qualification in this context; guidance on public engagement in OAE, for example, explicitly distinguishes Indigenous Peoples as rights-holders rather than stakeholders, recognising that their involvement entails rights and responsibilities that cannot be addressed through generic consultation alone (Satterfield et al., 2023). This distinction is consistent with the United Nations Declaration on the Rights of Indigenous Peoples, which recognises participation in decisions affecting their rights through representatives chosen by themselves and provides for consultation and cooperation in good faith to obtain free, prior and informed consent in the circumstances.[44] Accordingly, we treat "stakeholder-centred" as an organising term while recognising Indigenous rights-holders from other interested or affected actors.

These differences in rights, responsibilities and affectedness should shape the design of engagement. Stakeholders, especially those within CPr networks[45]are not only sources of knowledge, expertise and resources but also critical agents in shaping outcomes, mitigating risks and promoting adoption (Röschel, & Neumann, 2024). A stakeholder-centred approach emphasises participatory processes that integrate multiple perspectives, recognising that complex socio-technical systems cannot be effectively addressed through top-down or technocratic strategies alone.

Stakeholder-centred design and participation are not conceived here as an additional substantive dimension of the framework. Rather, they constitute a **cross-cutting governance process through which requirements identified across the five dimensions in Chapter 4 are operationalised**. Participation gives practical effect to legal requirements concerning transparency and procedural safeguards; ethical requirements concerning inclusion, equity and justice; scientific requirements concerning access to knowledge, transparency and independent scrutiny; and institutional requirements concerning accountable and legitimate decision-making. It can also make visible how economic incentives, risks and benefits are perceived and distributed among different actors.

This chapter develops that cross-cutting role through three interconnected components: the continuous identification and mapping of relevant actors; the integration of inclusion, equity and justice into participatory processes; and mechanisms for public engagement and co-creation. Together, these components explain how participation can inform governance decisions throughout the development of mCDR interventions.

[44] United Nations. (2007). United Nations Declaration on the Rights of Indigenous Peoples (A/RES/61/295), Articles 18–19 and 32. https://legal.un.org/avl/ha/ga_61-295/ga_61-295.html

[45] More detail on CPr can be found in Annex: Development of the Communities of Practice (CPr) network under Task 5.1.

5.1 Identifying and mapping stakeholders

Identifying and mapping stakeholders is the foundational step in stakeholder-centred design. Stakeholders encompass a broad spectrum of actors who influence, are affected by, or can contribute to mCDR research and potential implementation. These include EU and governmental institutions, regulatory authorities, private-sector actors and technology developers, civil-society organisations, research institutions, local and regional authorities, marine-dependent sectors, community groups and wider publics. Stakeholder-analysis literature emphasises that mapping should go beyond identifying actors and should also differentiate their interests, influence and relationships, as these characteristics shape both the design of engagement processes and the outcomes of environmental decision-making (Bryson, 2004; Malakar et al., 2025; Reed et al., 2009).

This is particularly important for mCDR because the actors with the greatest formal decision-making power are not necessarily those most directly affected by an intervention. mCDR is inherently place-based: interventions may interact with coastal livelihoods, existing uses of marine space, local ecosystems and culturally significant relationships with the ocean. mCDR needs to be understood as a local as well as a global governance problem, with local participation incorporated into assessment of site-specific interventions (Lezaun, 2021).

Workshops conducted as part of Task 4.3[46] showed that stakeholder mapping needs to distinguish roles as well as stakeholder categories. Participants repeatedly raised questions about who should propose an intervention, who should provide scientific information, who should organise consultation, who should monitor environmental performance and who should verify project-generated data. Particular concerns arise where a project developer may simultaneously act as the main source of information, organiser of participation and producer of monitoring evidence. Across the discussions, a general preference therefore emerged for clearer separation of these roles, with public or independent institutions retaining oversight functions and private actors contributing technical information within transparent governance arrangements. This corresponds with the wider emphasis in mCDR governance literature on independent scrutiny, transparent research and strong public oversight.

Stakeholder mapping should consequently categorise actors along several complementary dimensions:

a) Interest: the degree to which a stakeholder is affected by or concerned with mCDR outcomes;
b) Influence or power: the capacity to affect decisions, resource allocation, or implementation processes;
c) Contribution potential: the knowledge, resources, or expertise that a stakeholder can provide to strengthen outcomes;
d) Relationships and interdependencies: formal and informal networks connecting stakeholders, which can enable or constrain collaboration (WEF, 2022).

Analytical methods such as simplified influence-interest matrices as the one below, social network analysis and stakeholder typologies can facilitate systematic mapping, ensuring comprehensive coverage of both direct and indirect stakeholders. Mapping should also consider temporal dynamics, recognising that stakeholder relevance, influence and interests may shift, as well as contextual variations, which can

[46] See D4.3 for more information.

change stakeholder priorities and capacity for engagement across geographic, organisational, or cultural settings.

Interest	Low influence	High influence
High interest	Scientific networks Local municipalities Small-scale fishers	EU regulators, including DG CLIMA and DG MARE National maritime agencies Coastal and Indigenous communities NGOs
Low interest	General public Non-coastal populations	Trade and finance ministries Some industry actors from non-marine sectors

Table 4. Stakeholder influence vs. interest on mCDR

Stakeholder mapping should also be treated as dynamic rather than one-off. Stakeholder relevance, interests and influence may change as an intervention moves from laboratory research to field experimentation or possible larger-scale activity, while changes in location, technological configuration or environmental effects may create new affected groups. Mapping should therefore be reviewed at key transition points in the governance pathway and updated where project scale, location or risk profile changes. Effective stakeholder mapping is not only a technical exercise; it establishes the basis for engagement strategies, conflict mitigation and capacity-building interventions. It also ensures that marginalised or less visible groups are recognised and included, preventing biases that could compromise the legitimacy, inclusivity, or ethical integrity of the mCDR process.

5.2 Operationalising inclusion, equity and justice in stakeholder participation

Building on the ethical and social considerations discussed in Section 4.2, stakeholder-centred governance requires that participation is organised according to principles of inclusion, equity and justice. These principles are closely connected but perform different functions. Inclusion concerns who is able to participate; equity concerns whether different actors have a meaningful capacity to participate and influence the process; and justice concerns both the fairness of decision-making procedures and the distribution and recognition of the benefits, burdens and interests associated with mCDR. D5.1 similarly identifies meaningful inclusion, access to information and accountability to potentially affected stakeholders as minimum conditions of procedural justice and emphasises that power asymmetries can affect both participation and the distribution of risks and benefits.

1. Inclusion: active inclusion involves deliberately creating opportunities for participation by stakeholders who may otherwise be excluded due to social, economic, geographic, or institutional barriers. Inclusion ensures that diverse perspectives, including those of vulnerable or marginalised groups, inform the design and implementation of interventions, thereby improving relevance and broader acceptance. This is particularly important for mCDR where coastal communities, fisheries, Indigenous Peoples and other marine users may experience local environmental or socio-

economic effects despite having comparatively little influence over technology development or regulatory decisions. D5.1 draws on the **All-Affected Principle,** according to which those affected by a decision should have opportunities to participate in its making.

2. Equity: equity emphasises the fair distribution of resources, access and decision-making opportunities. It requires sensitivity to differentiated capacities, needs and vulnerabilities among stakeholders, ensuring that participation does not reinforce existing inequalities or power imbalances. Equity-oriented approaches may include capacity-building programmes, provision of resources to facilitate engagement and adaptive strategies to ensure meaningful participation for all actors.
3. Justice: justice extends the consideration of fairness to procedural and distributive outcomes. Procedural justice ensures transparent, accountable and inclusive processes that respect stakeholders' rights and contributions, while distributive justice addresses the equitable allocation of benefits and burdens arising from mCDR interventions. Incorporating justice principles strengthens legitimacy, social trust and the ethical grounding of decision-making processes.[47]

The application of these principles requires not only normative commitment but also practical mechanisms, such as targeted outreach, representative sampling in consultations and "iterative feedback loops". Addressing power asymmetries, ensuring accessibility and facilitating deliberative dialogue are critical to translating inclusion, equity and justice into concrete outcomes.

The workshops conducted within Task 4.3 provide practical support for these principles. Participants consistently stressed that affected communities and sectors should be involved early enough to influence the conditions under which an mCDR activity is designed and assessed, rather than being consulted only after major technical or siting decisions have been taken. At the same time, participants recognised that stakeholders differ substantially in technical expertise, institutional resources, access to decision-makers and capacity to participate over extended periods. A recurring concern, therefore, related to power asymmetries between actors. Commercial developers, public administrations and established research institutions may have considerably greater access to scientific information and policymaking processes than local organisations, small-scale marine users or individual citizens. Equal formal access to consultation consequently does not automatically produce equitable influence.

Applying inclusion, equity and justice requires practical mechanisms. Depending on the scale and stage of the intervention, these may include targeted outreach to less visible or affected groups; accessible and non-technical information; translation and accessibility measures; financial or logistical support for participation; capacity-building where technical complexity creates barriers; independent facilitation; sufficient time for deliberation; and iterative feedback mechanisms showing participants how their contributions have been considered. Where broader public consultation is intended, attention should also be paid to the representativeness and diversity of participants rather than relying predominantly on organised or highly resourced stakeholders.

Importantly, meaningful participation does not require that engagement produces consensus: legitimate disagreements may remain concerning acceptable levels of uncertainty, precaution, environmental risk, commercial involvement and the appropriate role of carbon markets. The purpose of an inclusive and

[47] Sustainability Directory. (2025, April 22). Why is justice important for stakeholder engagement? https://climate.sustainability-directory.com/question/why-is-justice-important-for-stakeholder-engagement

equitable process is therefore not to eliminate these differences, but to ensure that they are visible, fairly represented and traceable within the decision-making process.

5.3 Mechanisms for public engagement and co-creation

Operationalising stakeholder-centred design depends on appropriate mechanisms for public and stakeholder engagement. These mechanisms can range from the provision of information and consultation to deliberation and, where appropriate, co-creation. The distinction is important: communication primarily involves the transfer of information, consultation enables stakeholders to provide input, while more participatory approaches create opportunities for two-way exchange and for stakeholders to influence how problems and possible responses are defined (Rowe & Frewer, 2005). Co-creation represents a more intensive form of participation and can involve stakeholders in shaping elements of research, project design, monitoring arrangements or governance conditions. It should therefore not be treated as synonymous with all forms of engagement, nor as appropriate for every decision.

For emerging and uncertain technologies such as mCDR, the timing of engagement is particularly important. Responsible-innovation literature emphasises the value of “upstream” participation, in which societal questions are considered while technological pathways and institutional arrangements remain open to modification rather than after major choices have become embedded. Anticipation, reflexivity, inclusion and responsiveness can be identified as interconnected dimensions of responsible innovation, with deliberation incorporated into the innovation process itself (Stilgoe & Macnaghten, 2013).

The Task 4.3 workshops provide direct evidence of the value of deliberative approaches for mCDR governance. Structured stakeholder exercises enabled participants to move beyond general positions of support or opposition and identify specific conditions under which research or piloting might be considered acceptable. These included requirements relating to permitting, MRV, independent monitoring, ecological safeguards, transparency, institutional responsibility, local involvement and the distinction between research and commercial deployment. Similar findings emerge from community-based research on OAE. Nawaz and Belotti (2025) show that deliberative scenario exercises enabled participants to consider not only environmental impacts but also infrastructure, ownership, political-economic arrangements and the distribution of social benefits and burdens. Their findings further demonstrate that stakeholder preferences are neither necessarily fixed nor reducible to simple measures of support or opposition.

An important lesson from Task 4.3 is therefore that the purpose of deliberation should not necessarily be to achieve consensus. Across the workshops, disagreement persisted over the appropriate pace of technological development, the role of carbon markets, the treatment of commercially sensitive information, the timing of public engagement and the threshold for movement from pilot projects towards larger-scale activity. Surfacing these differences is itself a valuable governance outcome because it helps distinguish questions that may be addressed through additional scientific evidence from those involving political priorities, ethical judgments, acceptable levels of risk or distributive choices. Engagement should consequently provide a structured space in which such disagreements can be articulated and considered rather than treating dissent as a failure of the participatory process.

Another recurring finding concerned the institutional design of engagement. Participants supported cooperation between scientific institutions, public authorities, communities and private actors, but

repeatedly emphasised the need for clear responsibilities, independent oversight and transparent access to relevant information. Participatory governance should therefore not dissolve institutional accountability. Rather, co-creation should operate within a framework in which public authorities retain responsibility for legitimate authorisation and oversight, scientific and monitoring claims can be independently scrutinised, and project proponents cannot unilaterally determine either the evidence presented to participants or the terms on which participation takes place.

Engagement should also begin sufficiently early to influence project design. Consultation undertaken only after the main technological, siting or commercial decisions have already been made risks becoming symbolic and may reinforce mistrust. Early engagement can instead help identify locally relevant concerns, potential environmental and livelihood impacts, alternative project configurations and conditions that should be incorporated into research or permitting. For mCDR, this may include involvement in defining research questions, identifying relevant local knowledge, considering siting alternatives, developing environmental safeguards and determining which impacts should be monitored. Early engagement does not imply that every stakeholder shares formal decision-making authority, but it should create a genuine possibility for participation to affect the development of the intervention.

Effective mechanisms may include:

a) Participatory workshops and deliberative forums: structured in-person or virtual sessions that allow stakeholders to discuss challenges related to mCDR, generate ideas and collaboratively design solutions;
b) Digital engagement platforms: tools for broader public consultation on mCDR, feedback collection and knowledge sharing, enhancing broader participation;
c) Stakeholder advisory boards and multi-stakeholder councils: formal governance structures that integrate stakeholder input into strategic and operational decisions;
d) Collaborative prototyping and pilot testing: iterative processes where stakeholders actively contribute to the development and refinement of solutions, ensuring usability.[48]

The choice of mechanism should depend on the purpose of engagement, the stakeholders involved and the stage and risk profile of the activity. Not every governance question requires the same intensity of participation. General information provision may be sufficient for some research activities with minimal external effects, whereas field experiments or activities with direct implications for marine users and coastal communities may require more intensive deliberation and continuing engagement. As scale, duration, environmental uncertainty or potential affectedness increases, the scope and intensity of participation should similarly be reassessed.

Across these mechanisms, several design requirements are particularly important: transparency, independence, accessibility, responsiveness and traceability. Participants should receive sufficiently clear and balanced information about the purpose of the activity, the state of scientific knowledge, uncertainties, possible benefits and risks, the identity and interests of the actors involved and the extent to which the participatory process can actually influence decisions. Engagement should also incorporate feedback loops through which participants can see how their input has been considered and, where recommendations have not been followed, why. This responsiveness is important for preventing engagement from becoming a one-way exercise in communication or an instrument for generating

[48] See D4.3 for detailed information.

acceptance. The responsible-innovation framework similarly treats responsiveness as the capacity to change the direction or design of innovation in response to emerging knowledge and societal perspectives (Stilgoe & Macnaghten, 2013), public engagement and co-creation should be understood as continuing governance functions rather than one-off consultation events. The appropriate mechanisms and participants may change as an activity moves from research towards field experimentation or possible larger-scale application, and engagement should be revisited where new evidence, locations, affected groups or governance questions emerge.

6 From framework to action: pathways and recommendations

Building on the analytical findings and governance dimensions developed in the preceding chapters, this chapter translates the multi-dimensional mCDR governance framework into practical guidance for decision-making. The chapter is structured around three elements: guiding principles for effective mCDR governance; enabling conditions and governance pathways for progression from research towards possible larger-scale deployment; and policy and institutional recommendations at EU and international levels.

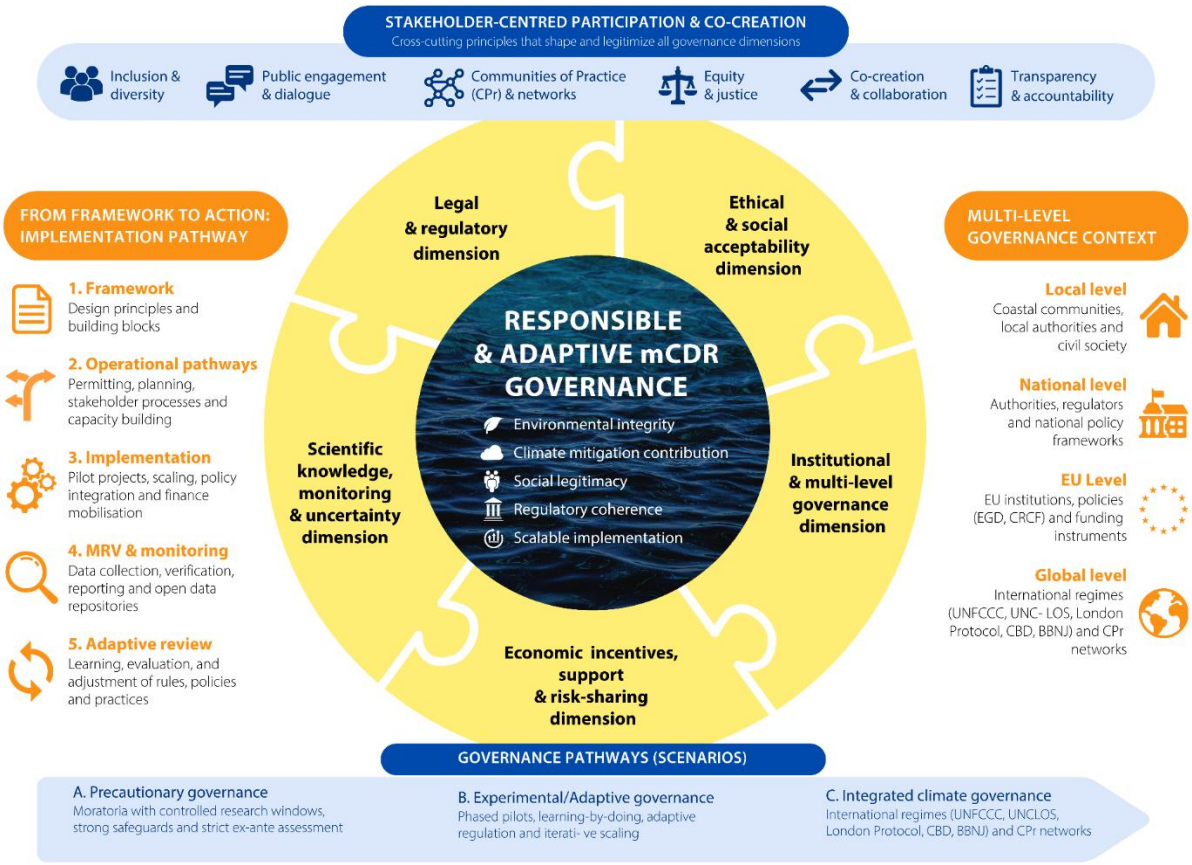

Figure 3. Multidimensional model for mCDR governance

6.1 Guiding principles for effective mCDR governance

The guiding principles below synthesise the five interdependent dimensions of the multi-dimensional framework developed in Chapter 4 and the stakeholder-centred approach developed in Chapter 5. They should not be understood as exclusively legal principles or as establishing a hierarchy in which regulatory considerations precede scientific, ethical, economic, institutional or societal ones. Rather, they provide cross-cutting criteria for integrating these dimensions into coherent, responsible and adaptive governance

decisions. Their application should remain technique-, stage- and context-sensitive, reflecting the characteristics of the intervention and the decision under consideration.

1. **Coherence and integration across governance functions are foundational.** Effective mCDR governance requires coherence not only among applicable legal regimes, but also across scientific assessment, environmental monitoring, carbon accounting, institutional responsibilities, economic support and stakeholder processes. From a legal perspective, decision-makers should approach UNCLOS, the LC/LP, CBD practice, regional seas arrangements and, where applicable, the EU acquis as an interconnected normative landscape rather than as separate regulatory silos. Relevant obligations may operate cumulatively and should therefore be applied coherently while preserving their respective functions and standards.

   More broadly, coherence also requires the different components of the governance framework to reinforce rather than undermine one another. Research and innovation support should be aligned with the capacity to generate and assess relevant evidence; carbon-removal certification should remain connected to, but distinct from, environmental authorisation; economic incentives should develop in step with scientific and regulatory readiness; and participatory processes should be embedded within institutional decision-making rather than operating as separate consultation exercises. Coherence should therefore be understood as an ongoing governance function rather than a one-off feature of institutional design.

2. **Precaution and evidentiary adequacy should guide decision-making under uncertainty.** Where environmental effects remain uncertain or may be serious or difficult to reverse, precaution supports more demanding ex ante assessment, additional evidence requirements, conditional authorisation or, where appropriate, non-progression. The intensity of precaution should reflect the scale, footprint, duration, reversibility and potential consequences of the activity.

   At the same time, precaution does not necessarily exclude carefully bounded research where uncertainty can be managed through appropriate safeguards, monitoring and predefined review conditions. Consistent with the whole-system understanding of readiness developed in the framework, the relevant question is not whether uncertainty has been eliminated, but whether the available evidence is sufficiently robust for the particular decision and stage under consideration. Scientific uncertainty should therefore be made explicit and incorporated into decision-making rather than treated either as an automatic barrier to research or as a reason to presume safety.

3. **Proportionality and stage-sensitive governance should connect requirements to the characteristics of the intervention.** Governance requirements should reflect the technique, stage, scale, duration, location and risk profile of the activity. The evidentiary burden, environmental safeguards, level of institutional oversight, intensity of stakeholder engagement and form of economic support should therefore evolve as an intervention moves from research towards field experimentation and, where justified, possible larger-scale application.

   A stage-sensitive approach helps avoid two opposite risks: imposing requirements designed for commercial or larger-scale activities on carefully controlled research in ways that prevent useful evidence generation, and allowing requirements appropriate to early-stage research to remain unchanged as the environmental, economic or societal implications of an intervention increase. Where relevant, consideration of alternatives should also identify whether the intended carbon-

removal objective could be pursued through a less environmentally harmful location, configuration, operating condition or scale. The reasoning behind such assessments should be transparent and, where applicable, reflected in environmental assessment and authorisation processes.

4. **Environmental and carbon-removal integrity should remain distinct but connected**. Carbon-removal outcomes should be supported by sufficiently robust MRV and should be traceable to the activity from which they originate. Environmental monitoring and carbon-removal MRV may draw on related evidence and monitoring infrastructure and should therefore be interoperable where appropriate, while remaining functionally and conceptually distinct.

   This distinction is fundamental to the multi-dimensional framework. Evidence sufficient to demonstrate a measurable carbon-removal outcome does not necessarily demonstrate that the underlying intervention is environmentally acceptable, while environmental authorisation does not itself establish the validity or durability of a carbon-removal claim. Carbon certification should therefore not substitute for environmental authorisation, and environmental legality should not automatically confer economic or climate-policy value on an unverified removal claim. The objective is to maintain a transparent chain between the lawfulness of the activity, its environmental performance and the integrity of any subsequent carbon-removal claim. This principle reflects the framework's broader whole-system approach, in which technological operation, carbon-removal performance and environmental consequences are assessed as interconnected but non-interchangeable elements.

5. **Participation and social legitimacy are constitutive elements of responsible governance** mCDR governance should address both the distribution of risks, burdens and benefits and the fairness of the processes through which decisions are taken. Participation should therefore begin sufficiently early for affected actors to influence project and governance conditions rather than being added after key technological, siting or commercial choices have already been made. Particular attention should be given to affectedness and differentiated capacity to participate, so that coastal communities, Indigenous Peoples, marine-dependent sectors and other actors with limited institutional influence are not overlooked. Meaningful participation also requires accessible information, transparency concerning who generates and verifies evidence, opportunities to express disagreement and feedback mechanisms through which participants can understand how their contributions have been considered.

   Participation should not be treated as a means of generating acceptance or consensus. Legitimate disagreement may remain over acceptable uncertainty, environmental risks, commercial involvement or the appropriate conditions for progression. The function of stakeholder-centred governance is therefore to ensure that these differences are visible, fairly represented and capable of informing decision-making. In the European context, the Aarhus Convention provides an important procedural reference point concerning access to information, public participation and access to justice in environmental matters.

6. **Substantive and distributive justice** require attention to who benefits from mCDR research and potential deployment, who bears environmental, socioeconomic or long-term risks and how these effects are distributed across communities, states and generations. Procedural justice requires meaningful opportunities for potentially affected actors to participate in relevant decisions.

7. **Accountability, institutional capacity and fair allocation of risk should make responsibilities identifiable and enforceable.** Governance arrangements should clarify the respective responsibilities of public authorities, project developers and other actors for authorisation, implementation, MRV, remediation, data retention and long-term stewardship. Accountability also requires institutions with sufficient scientific, administrative, monitoring and enforcement capacity to exercise these responsibilities effectively. The existence of a formally competent authority or permit is not sufficient where the responsible institutions lack the capacity to assess evidence.

   The allocation of legal responsibility should be distinguished from, but coordinated with, the economic allocation of project-related risks. Public support for emerging technologies should not automatically result in the costs of underperformance, reversal, environmental damage or long-term monitoring being transferred to the public sector. Where appropriate, financial-security and risk-sharing arrangements, including insurance, bonding, reserve mechanisms or performance-dependent payments, may help allocate financial risks in accordance with the characteristics of the intervention. At the same time, operator-level responsibility does not remove relevant State responsibilities under international law. For marine scientific research, UNCLOS Article 263 provides a specific responsibility and liability framework, while wider marine-environmental responsibilities of States remain relevant under UNCLOS more generally.

8. **Adaptive learning, policy alignment and non-undermining cooperation should connect implementation with continuous review.** mCDR governance should preserve the ability to revise decisions as scientific evidence, monitoring results, technologies, societal expectations and institutional conditions evolve. Authorisations should, where appropriate, include monitoring requirements and predefined review triggers allowing conditions to be maintained, strengthened or modified, and activities to be paused or terminated where new evidence changes the assessment of risk or performance. Adaptive governance therefore turns monitoring and evidence generation into inputs to continuing decision-making rather than treating them as purely reporting exercises.

   Adaptation should also apply to policy support and institutional arrangements. Research funding, innovation support, carbon-removal incentives and regulatory requirements should evolve together with the scientific and governance maturity of an intervention. This is important to ensure that incentives do not create pressure for premature progression, while regulatory requirements do not unnecessarily prevent controlled research capable of reducing relevant uncertainties.

9. Finally, adaptation should occur within the **principle of non-undermining cooperation**. New governance processes should complement rather than weaken existing safeguards, and coordination across institutional levels should preserve applicable environmental and procedural standards. In particular, procedures emerging under the BBNJ Agreement should be implemented coherently with relevant UNCLOS, LC/LP and regional arrangements rather than being treated as substitutes for them. Cooperation should also support shared learning, information exchange and the gradual development of common expectations while retaining sufficient flexibility to account for differences among mCDR techniques and contexts. The key change is to connect it explicitly to scientific learning, economic support and institutional coordination rather than treating it mainly as a legal cooperation principle.

Taken together, these principles provide a common basis for integrating the different dimensions of the framework without subordinating one to another. Their purpose is not to prescribe a uniform governance model for all mCDR approaches, but to guide the application and coordination of legal, ethical and social,

scientific, economic and institutional requirements in a manner that remains responsive to technique, stage, scale and context. They provide the conceptual bridge between the building blocks developed in Chapters 4 and 5 and the enabling conditions and governance pathways set out in the following sections.

Figure 4. Guiding principles for effective mCDR governance

6.2 Governance pathways (scenarios)

The five governance dimensions developed in Chapter 4 and the participatory approach outlined in Chapter 5 can inform different responses to the uncertainties surrounding mCDR. Recent foresight research illustrates the value of exploring alternative policy futures under changing scientific, political and societal conditions (Boettcher, 2023). NASEM (2026) similarly emphasise the importance of distinguishing research from deployment and adapting oversight to changes in activities and actor configurations. Drawing on these insights, the pathways below present three illustrative governance responses.[49]

Precautionary and research-limited pathway

Where scientific uncertainty remains high, potential environmental effects may be serious or difficult to reverse, the applicable legal characterisation is unresolved, or regulatory and monitoring capacity is insufficient, governance may appropriately remain precautionary. In such circumstances, the permissible scope of activity may be limited to laboratory research or carefully controlled field experimentation, while broader deployment is deferred. This pathway may involve restrictions or temporary moratoria on particular forms or scales of intervention, accompanied by narrowly defined research windows designed to generate evidence necessary for future regulatory assessment. Authorisation should be subject to enhanced environmental assessment, clear spatial and temporal limits, independent monitoring, transparency requirements and predefined review or stop conditions. Where relevant, existing

[49] These pathways will be further explored and refined through deliberative workshop activities under Task 4.3.

obligations under UNCLOS, the LC/LP, regional arrangements and the BBNJ Agreement should operate cumulatively rather than as alternative routes to authorisation. Precaution therefore does not necessarily prohibit research, but requires that experimentation is bounded by safeguards proportionate to the uncertainty and potential consequences involved. Under this pathway, the appropriate outcome of research may remain continued research or non-progression, rather than eventual deployment. This is particularly important where evidence generated through experimentation does not sufficiently resolve environmental, legal or governance uncertainties.

This pathway reflects the distinction between responsible learning and deployment discussed by the NASEM (2026). Its purpose is to generate evidence relevant to future decisions without presuming that deployment will follow.

Experimental and adaptive governance pathway

Where limited field experimentation can be legally authorised and relevant risks are considered manageable, mCDR may proceed through an adaptive governance pathway based on conditional and reviewable authorisation. Rather than granting permission for an entire technological trajectory, regulators would authorise defined stages of activity and reassess the conditions for continuation as new evidence becomes available. The pathway would link research, permitting, environmental monitoring and carbon-removal MRV through predefined decision points. Authorisations could specify baseline-data requirements, monitoring and disclosure obligations, independent scientific assessment, responsibility for remediation and data retention, and triggers for modification, suspension or termination. A material change in scale, duration, location or environmental footprint should trigger renewed assessment rather than relying automatically on an earlier research permit. This pathway is particularly compatible with the hybrid governance dynamics identified in D5.1. States and other actors may cooperate on scientific standards, data sharing, MRV and environmental safeguards while retaining different national approaches to permitting, innovation policy or commercialisation. Such cooperation can develop through transnational communities of practice linking scientists, MRV practitioners and regulators, where sustained exchange supports shared methods, monitoring practices and interpretations of evidence (see Section 4.3). These practices may subsequently inform formal standards and regulatory arrangements, while decisions on their adoption remain with the competent institutions.

The governance objective is therefore not complete uniformity, but sufficient interoperability to enable regulatory learning while avoiding premature scale-up or regulatory arbitrage. D5.1 similarly envisages a hybrid landscape in which technical cooperation may coexist with competition over technology, investment and emerging governance standards. Stakeholder participation should form part of this adaptive process. As the scale, location or commercial purpose of an activity changes, the range of affected actors may also change, requiring stakeholder mapping and engagement to be revisited rather than treated as completed at the research stage.

Coordinated integration into EU and international governance frameworks

Where an mCDR approach reaches a higher level of scientific, regulatory and institutional maturity, a third pathway involves its progressive integration into existing climate, marine and carbon-removal governance frameworks. This pathway would be appropriate only where carbon-removal performance and durability can be credibly demonstrated, environmental risks can be assessed and monitored, applicable legal gateways are sufficiently clear, responsible institutions possess adequate supervisory capacity and social legitimacy can be maintained. At EU level, this could involve the development of relevant CRCF methodologies, closer coordination between climate and marine-policy institutions and the alignment of

research, environmental authorisation, carbon accounting and financial-support instruments. Integration should nevertheless preserve the distinction between carbon certification and environmental legality: a recognised removal claim should not provide an alternative route around applicable marine environmental requirements. At international level, this pathway would rely primarily on stronger coordination through existing institutions rather than the creation of a wholly separate mCDR regime. UNCLOS, the LC/LP, the BBNJ Agreement and other applicable frameworks could provide the basis for increasingly common expectations concerning environmental assessment, MRV, monitoring, information sharing, transboundary consultation and accountability.

A cross-cutting risk across these pathways is the emergence of a fragmented and predominantly competitive governance trajectory. Where technological development, commercial incentives or national innovation strategies advance more rapidly than regulatory coordination, states may adopt divergent standards and authorisation practices, creating incentives for jurisdiction shopping, regulatory arbitrage and competing approaches to MRV and carbon accounting. This risk is particularly relevant for technologically and commercially scalable approaches, where competition for technological leadership and influence over emerging standards may reinforce institutional fragmentation.

6.3 Policy and recommendations

The following recommendations translate the analytical findings into policy and institutional priorities at two complementary levels of governance: the EU and the international level. They are intended to support the development of a more coherent, transparent and adaptive framework for the responsible governance of mCDR, and will be further developed and released as part of the SEAO2-CDR project's wider dissemination activities within WP8 (D8.2).

At the EU level

1) **Continue to develop evidence-based and technique-specific pathways for the potential inclusion of relevant mCDR approaches under the Carbon Removal Certification Framework.**

The implementation of the CRCF should progressively incorporate relevant mCDR approaches through clear, technique-specific methodologies. These methodologies should reflect the particular characteristics of marine interventions, including challenges concerning quantification, permanence, environmental impacts and transboundary effects, and should be developed only where the underlying scientific evidence is sufficiently robust. Any future CRCF methodology for mCDR should also ensure compatibility with applicable marine environmental law. Carbon-removal certification and environmental authorisation should remain clearly differentiated: certification should demonstrate the integrity of a carbon-removal claim, but should not be treated as evidence that the underlying marine intervention is lawfully authorised or environmentally acceptable. At the same time, environmental monitoring and carbon-removal MRV should become interoperable where technically and legally appropriate so that relevant information can inform permitting, environmental assessment and carbon verification without conflating their different purposes.

2) **Strengthen cross-sectoral EU coordination for mCDR governance.**

Greater institutional coordination is required, as mCDR sits at the intersection of climate mitigation, marine environmental protection, research and innovation, the blue economy and emerging carbon-removal policy. A specialised coordination mechanism or task force could bring together relevant Commission services, particularly DG CLIMA and DG MARE, alongside environmental, research and

innovation actors, Member State authorities and relevant existing expert structures. Such a mechanism could build on existing structures, including the Expert Group on Carbon Removals, rather than necessarily requiring the creation of a completely new standalone institution. Its role should be to improve coherence between climate policy, marine regulation, research support and future carbon-removal governance; facilitate exchange between regulators and scientific experts; and help translate emerging scientific evidence into regulatory and policy practice. The mechanism could also support the development of accessible guidance for project developers and research actors on applicable EU and national regulatory pathways, competent authorities and procedural requirements.

3) Align EU research, innovation and financial support with stage-specific scientific and governance readiness.

There is a risk of a mismatch between regulatory systems, which govern whether and under what conditions projects may proceed, and promotion systems, which support research, innovation and potential deployment. Research funding may otherwise support activities for which no workable permitting pathway exists, while highly developed regulatory frameworks may remain ineffective in the absence of sufficient scientific infrastructure and research support. Public support should therefore remain stage-sensitive. Early-stage funding should prioritise knowledge generation, environmental baselines, monitoring infrastructure and controlled experimentation. Support for demonstration activities and stronger demand-side mechanisms, including public procurement, carbon contracts for difference or participation in carbon markets, should become relevant only where removal outcomes can be credibly quantified and appropriate environmental, regulatory and governance safeguards are sufficiently developed. EU policy should also support Member States in developing the scientific, administrative and enforcement capacities required to assess and supervise mCDR activities, including common guidance on regulatory screening, environmental assessment, monitoring, stakeholder participation and transboundary consultation.

4) Embed meaningful participation, equity and social legitimacy in EU mCDR research, authorisation and support processes.

EU-level guidance should ensure that stakeholder participation is incorporated sufficiently early to influence relevant research, siting, environmental-assessment and governance conditions. Depending on the scale, location and potential affectedness of an intervention, appropriate stakeholder and community engagement should form part of project authorisation and, where relevant, conditions attached to public research or innovation funding. Particular attention should be given to actors that may be highly affected but possess comparatively limited institutional influence, including coastal communities and marine-dependent sectors. Participation should be supported by accessible information and transparent feedback on how stakeholder input has been considered.

At the international level

5) Promote appropriate consideration of mCDR in relevant Paris Agreement processes, supported by credible and interoperable MRV approaches.

The role of carbon removals, including potentially ocean-based approaches, should be more systematically considered in international climate-policy review processes, including the Global Stocktake, while maintaining the principle that removals complement rather than replace emissions reductions. This should be accompanied by the gradual development of common and interoperable approaches to MRV. Full harmonisation across all mCDR techniques is unlikely to be appropriate given their technological and environmental diversity. Nevertheless, minimum common expectations should be developed concerning

quantification, durability, environmental baselines, disclosure, independent verification and the treatment of uncertainty. Strong MRV and transparency are particularly important because they link the environmental and legal integrity of an intervention with the credibility of any associated climate claim and help reduce risks of double counting and greenwashing.

6) **Advance international convergence on definitions, legal characterisation and minimum governance safeguards.**

International cooperation should seek greater clarity regarding the legal characterisation and governance of different mCDR techniques under existing regimes, particularly UNCLOS, the London Convention and London Protocol, the Convention on Biological Diversity and the BBNJ Agreement. This should not imply treating all mCDR activities as a single legal category. D5.1 demonstrated that different technique families engage different regulatory gateways and procedural requirements and that legal obligations become progressively more demanding as scale, footprint, foreseeability of harm and transboundary reach increase. International efforts should therefore focus on establishing minimum common expectations concerning environmental assessment, monitoring, precaution, transparency and cooperation while retaining technique-specific requirements. Particular attention should be given to clear triggers for transboundary notification, consultation, information sharing and, where appropriate, coordinated monitoring when activities may affect other states or areas beyond national jurisdiction. International cooperation should also consider the distributional implications of mCDR activities, particularly where interventions take place in ABNJ or generate benefits and risks across jurisdictions. Relevant governance processes should explore appropriate approaches to benefit-sharing, capacity-building and access to scientific knowledge and monitoring capabilities, particularly for states with limited technological and financial capacity.

7) **Develop or strengthen an international transparency and information-sharing mechanism for mCDR projects.**

Greater transparency is needed as mCDR research and potential commercial activity expand across jurisdictions. An international registry, or an interoperable set of public information-sharing mechanisms, should be developed for publicly and privately funded mCDR research, pilots and larger-scale interventions. Such a mechanism could include basic information concerning project location and scale, responsible public and private actors, funding sources, authorisation status, environmental assessment and monitoring arrangements, MRV methodologies and reported carbon-removal outcomes. Where applicable, it could build on existing or emerging information-sharing structures under international marine governance frameworks rather than duplicating them. Improved transparency would facilitate independent scrutiny, international cooperation and regulatory learning while helping to reduce the risks of greenwashing, double counting, jurisdiction shopping and regulatory arbitrage.

8) **Support inclusive international CPr, as well as place capacity-building and equitable participation at the centre of mCDR governance.**

International scientific and policy CPr should be strengthened to support the exchange of scientific evidence, monitoring methods, regulatory experience and lessons from research and pilot activities. Sustained cooperation can help develop shared practices that subsequently inform governance arrangements, and these networks can connect with relevant international scientific and policy processes while supporting, rather than replacing, accountable decision-making by competent institutions. Their membership and activities should extend beyond established expert and industry networks. D5.1 and D5.2 identify the risk that actors with greater scientific, financial and institutional resources disproportionately influence emerging standards and governance pathways; addressing this imbalance requires meaningful

participation by developing countries, Small Island Developing States, affected coastal communities, civil-society organisations and marine-dependent sectors, alongside explicit recognition of Indigenous Peoples as rights-holders. These actors should have opportunities to shape research questions, assessment priorities and proposed safeguards, rather than being consulted only after key choices have been made. Cooperation should also support exchange among developing countries through South–South partnerships, complemented where appropriate by triangular cooperation involving additional technical or financial partners. Joint research, exchanges among regulators and community-led knowledge sharing could enable participants to develop and adapt approaches suited to their own priorities and marine contexts. Capacity-building should therefore strengthen their ability to shape governance, as well as to implement existing methods and standards.

The EU and its Member States could support these objectives through relevant research, external-cooperation and capacity-building instruments, subject to their objectives and eligibility conditions. Support should respond to priorities identified with participating countries and communities and strengthen lasting scientific, monitoring and regulatory capacity. Its effectiveness should be assessed through participants' ability to influence agendas and decisions, alongside improvements in access to knowledge, resources and institutional cooperation.

9) Promote minimum common expectations for accountability, liability and financial-security arrangements, linking legal responsibility with the allocation of financial risk.

Governance frameworks should clearly allocate responsibility among public authorities, project developers and other actors for compliance, monitoring, remediation, reversal risks, data retention and long-term stewardship. The involvement of private operators should not result in environmental or financial risks being automatically transferred to states or the wider public. Appropriate financial-security mechanisms, including insurance, bonding, reserve funds, escrow arrangements or equivalent instruments, should therefore be considered according to the specific risk profile of the technique and activity. Permit design is closely connected to liability allocation: failure to establish clear responsibility for monitoring, remediation or failed sequestration may leave public authorities exposed to residual financial and legal liabilities. Accountability provisions should also remain compatible with relevant State responsibilities under international law and should be reviewed as activities move from research towards larger-scale and potentially commercial deployment.

7 Conclusions

This deliverable has developed a multi-dimensional governance framework for mCDR by translating the findings of tasks conducted within WP5 of the SEAO2-CDR project (as well as those conducted within other components of the project) into an operational model that incorporates legal and regulatory arrangements; ethical and social acceptability; scientific knowledge, monitoring and uncertainty; economic support and risk-sharing; and institutional and multi-level governance. Participation provides a cross-cutting process through which these dimensions can inform decisions in practice.

The analysis reinforces the finding that mCDR governance faces fragmentation, incomplete coordination and uneven institutional capacity, rather than a complete absence of relevant rules. Existing international, EU and national arrangements provide important foundations, but their application varies across techniques, locations and stages of development. The task is therefore to clarify and connect these arrangements while addressing substantive gaps and strengthening the capacity to implement them.

The analysis demonstrates that the principal governance challenge facing mCDR is not the absence of relevant rules: existing international, EU and national frameworks already provide important legal and institutional foundations. Rather, the challenge lies in their fragmentation, incomplete coordination and uneven capacity to translate general obligations into coherent decisions concerning particular techniques, locations and stages of technological development. This conclusion aligns with concerns about governance adequacy and coordination raised in recent assessments, including Brun et al. (2026) and the Ocean Panel Blue Paper (Doney et al., 2025), and sits within the broader discussion of scientific uncertainty and governance needs addressed by GESAMP (2025). Accordingly, there is unlikely to be a single governance regime suitable for all forms of mCDR. Different techniques engage different legal gateways, involve different environmental and social risks and present different levels of scientific uncertainty.

Effective governance for mCDR should therefore be technique-specific, stage- and scale-sensitive, adaptive and multi-level. Cross-cutting principles of coherence and integration, precaution and evidentiary adequacy, proportionality, environmental and carbon integrity, justice and participation, accountability and adaptive learning could provide a common basis for applying the framework, while their practical implications vary according to the technique, stage, scale and context of individual interventions.

A central implication is that scale-up should be treated as a conditional governance decision rather than as the automatic consequence of successful research or technological development. Progression from research to field experimentation and potentially larger-scale deployment should depend on the accumulation of sufficient scientific evidence, credible environmental monitoring and carbon-removal MRV, regulatory and institutional capacity, continuing social legitimacy and appropriate arrangements for allocating financial and environmental risks. Where these conditions have not been met, legitimate governance outcomes may include continued research, modification of the intervention, additional safeguards, temporary suspension or non-progression. Across these pathways, mCDR should remain complementary to, rather than a substitute for, rapid and sustained emissions reductions, and governance arrangements should guard against mitigation deterrence and technological lock-in. Decisions should

explain how these criteria have been satisfied, what uncertainties remain and which findings or changes would trigger reassessment.

No single dimension of governance provides the foundation for the others: legal permissibility, ethical and social legitimacy, scientific readiness, economic support and institutional capacity address distinct but interdependent governance questions, while stakeholder-centred participation provides a cross-cutting means of operationalising several of these requirements. However, these governance dimensions cannot operate independently. Carbon-removal certification cannot substitute for environmental authorisation, just as environmental authorisation does not by itself demonstrate the validity of a carbon-removal claim. Environmental monitoring and carbon MRV should therefore remain functionally distinct while becoming sufficiently interoperable to allow evidence to inform both regulatory oversight and the integrity of removal claims. Similarly, economic support should develop in step with regulatory and scientific readiness so that public funding or carbon-market incentives do not create pressure for premature commercialisation.

Stakeholder participation is a constitutive element of responsible mCDR governance rather than an additional communication activity. The findings underline the importance of early and continuing engagement, particularly with actors who may be highly affected but possess comparatively little institutional influence. Participation should make disagreements and trade-offs visible rather than being designed simply to generate acceptance or consensus. The stakeholder work conducted within the project confirms that questions of permitting, independent monitoring, ecological safeguards, transparency, responsibility and the boundary between research and commercial deployment are central to perceptions of legitimate mCDR governance.

These findings point towards an adaptive governance architecture capable of enabling responsible learning without creating a presumption of deployment. Its purpose is neither to accelerate mCDR irrespective of risk nor to prevent experimentation by default, but to establish credible pathways through which evidence, environmental integrity, legal compliance, institutional capability and societal considerations can be assessed together. At both EU and international levels, the priority should consequently be to improve the coherence and interoperability of existing governance arrangements, strengthen capacity and transparency, and preserve the ability to revise decisions as technologies, evidence and societal expectations evolve.

8 Deviations from Annex 1

No deviations from Annex 1.

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Project partners:

#	Partner	Partner full name
1	UNR	Uniresearch
2	iDiv	Universitaet Leipzig
3	IfW Kiel	Institut fuer Weltwirtschaft
4	ULEI	Universiteit Leiden
5	GEOMAR	Helmholtz-Zentrum fur Ozeanforschung Kiel
6	WOC	World Ocean Council Europe
7	CASE	Centrum Analiz Spoleczno-Ekonomicznych - Fundacja Naukowa
8	COMILLAS	Universidad Pontificia Comillas
9	LUISS	Libera Universita Internazionale degli Studi Sociali Guido Carli
10	CAU	Christian-Albrechts-Universitaet zu Kiel
11	UCAM	The Chancellor Masters and Scholars of the University of Cambridge
12	HWU	Heriot-Watt University
13	NOC	National Oceanography Centre
14	EUI	European University Institute

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11 Annex: Development of the Communities of Practice (CPr) network under Task 5.1.

11.1 Purpose of the CPr within WP5

CPr developed under T5.1 were designed as a stakeholder-oriented mechanism supporting the broader objectives of Work Package 5. WP5 aimed to develop a scientifically grounded, stakeholder-oriented and multi-dimensional governance framework for mCDR. In this context, the CPr was not conceived as a separate dissemination activity, but as an integral part of the process through which the governance framework could be informed by practical knowledge, institutional experience and stakeholder perspectives.

The rationale for establishing the CPr network was that responsible mCDR governance cannot be developed solely through desk-based legal, ethical or policy analysis. mCDR questions that cut across scientific uncertainty, environmental risk, permitting and authorisation procedures, ethical acceptability, public legitimacy, economic feasibility and multi-level institutional coordination. Many of these questions can only be meaningfully assessed by engaging actors who are directly involved in, or have relevant knowledge of, research, regulation, environmental protection, marine governance, climate policy, carbon markets, civil society advocacy or potential implementation contexts.

The CPr therefore served several interconnected purposes. First, it provided a structure for identifying and mapping relevant actors across different governance dimensions, including public authorities, scientific and research institutions, legal and policy experts, NGOs and civil society organisations, private-sector actors, local and regional stakeholders, and international or EU-level organisations. Second, it created channels for collecting expert and stakeholder input through interviews, consultations, expert exchanges and workshop-based engagement. Third, it supported the integration of these inputs into the legal, ethical, political and geopolitical analyses developed in D5.1 and into the multi-dimensional governance framework developed in D5.2. These exchanges also supported the comparison of findings from literature and regulatory analysis with practitioners' experience, helping to identify areas of convergence, differences in interpretation and implementation challenges.

A central role of the CPr approach was to connect different strands of the project that might otherwise remain analytically separate. In particular, it helped link the legal and policy analysis of mCDR governance with the stakeholder and public perception work carried out in Task 4.3, as well as with discussions on commercial, economic and implementation conditions addressed in other parts of the project. This was especially important because the governance of mCDR is not only a matter of identifying which legal instruments apply. It also requires understanding how different actors interpret uncertainty, responsibility, legitimacy, precaution, monitoring, benefit-sharing and possible pathways from research to piloting or scale-up.

The CPr also functioned as a bridge between D5.1 and D5.2. D5.1 established the legal, ethical and policy basis for the governance analysis, including the identification of applicable legal frameworks, ethical concerns and political or geopolitical implications of mCDR. D5.2 builds on this basis by translating these findings into a broader governance framework. The CPr contributed to this transition by providing practical insights into where governance challenges arise, what kinds of concerns stakeholders raise, and which decision points may require particular attention.

In this sense, the CPr should be understood as an engagement infrastructure rather than a one-off consultation exercise. Its purpose was not to produce a representative survey of all possible stakeholder views, nor to replace formal public consultation or regulatory procedures. Instead, it was intended to support structured knowledge exchange with relevant actors and to ensure that the governance model remains attentive to institutional practice, stakeholder concerns and real-world implementation challenges.

The development of the CPr also created a foundation for later-stage feedback, validation and dissemination of SEAO2-CDR governance results. By establishing and progressively expanding a network of relevant actors, the project created channels through which emerging findings can be discussed, refined and communicated. This includes engagement through expert interviews, deliberative workshops conducted in cooperation with WP4, and creation of a dedicated SEAO2-CDR 'mCDR' space within the stakeholder forum established by our 'sister' project UPTAKE. Together, these activities helped move the CPr from an initial stakeholder map towards an emerging engagement infrastructure for knowledge consolidation and stakeholder-informed governance development.

11.2 Phase I: Infrastructure development

The first phase of Task 5.1 focused on establishing the basic infrastructure for the CPr. The aim was to create the organisational and methodological conditions for later stakeholder engagement, rather than to generate substantive governance findings at this stage.

This phase included three main elements. First, relevant stakeholder categories were identified and mapped. These included scientific and research actors, public authorities and regulators, legal and policy experts, NGOs and civil society organisations, private-sector actors, local and regional stakeholders, and EU or international-level actors. This mapping reflected the broader ambition of WP5 to develop a stakeholder-oriented and multi-dimensional governance framework for mCDR.

Second, work was undertaken on basic engagement tools. These included a stakeholder contact database, interview and consultation protocols, baseline materials for discussion, and GDPR-related arrangements. These tools were intended to support later interviews, consultations, expert exchanges and workshop-based engagement.

Third, coordination links were established with other relevant parts of the project, especially WP4 and WP6. This was important because the CPr was expected to support not only WP5 governance analysis, but also stakeholder perception work, deliberative workshops and discussions on commercial and market-related aspects of mCDR governance.

The main result of Phase I was the creation of a functioning foundation for the CPr. By the end of this phase, the project had a mapped stakeholder base, basic engagement procedures and a structure that

could be used in the subsequent phases of Task 5.1. This enabled the task to move from infrastructure-building to active engagement through interviews, consultations and later deliberative workshops.

11.3 Phase II: Setting in motion

The second phase focused on activating the Community of Practice and beginning to use it as a source of input for WP5. While Phase I created the basic infrastructure, Phase II moved the CPr towards practical engagement with selected stakeholders and experts.

At this stage, the work concentrated on identifying relevant thematic entry points for discussion. These were closely connected to the analytical structure of WP5 and included legal feasibility, permitting and authorisation pathways, ethical and justice concerns, political and geopolitical barriers, MRV and monitoring, stakeholder inclusion, and potential conditions for responsible piloting or future scale-up.

The CPr was then used to support interviews, consultations and expert exchanges. These interactions helped to gather practical and interpretive knowledge from actors familiar with legal frameworks, policy processes, research conditions, environmental risks and governance challenges related to mCDR. In D5.1, these inputs were used to complement the legal, ethical and policy analysis, including through expert knowledge obtained via semi-structured interviews.

This phase was also important for clarifying the role of the CPr in relation to D5.2. The stakeholder input collected through the CPr did not function as a separate dataset detached from the governance framework. Rather, it helped ground the framework in practical concerns and institutional experience. This is consistent with the overall purpose of D5.2, which is to combine the findings of D5.1 with evidence from other work packages and stakeholder engagement undertaken through the CPr.

The main result of Phase II was that the CPr began to operate as an active engagement mechanism. It supported the development of WP5 outputs by creating channels for stakeholder and expert input, and by helping connect the conceptual analysis of mCDR governance with practical questions raised by actors working in relevant fields.

11.4 Phase III: Selection of sensitive intervention points

The third phase focused on identifying the points in decision-making and policy-making processes where mCDR governance questions become especially consequential. In the task description, these were defined as “sensitive intervention points”: specific processes that may create windows of opportunity for trialling, regulating or potentially upscaling selected OCDR techniques.

On the basis of the WP5 work carried out so far, these intervention points were not treated as single moments in a linear pathway, but rather as recurring governance situations in which legal, ethical, scientific and institutional choices need to be made. D5.1 shows that mCDR is already subject to existing legal obligations and should not be understood as operating in a legal vacuum. In particular, it points to requirements concerning environmental assessment, due diligence, monitoring, transparency and cooperation.

The main sensitive intervention points identified through WP5 work include:

Sensitive intervention point	Governance relevance
Legal classification of the activity	Determines whether a proposed intervention is treated as marine scientific research, dumping or placement, aquaculture or restoration, carbon storage, or
Permitting and authorisation	Establishes which authorities are competent and what conditions must be met before a pilot or larger activity can proceed.
Environmental assessment	Connects mCDR activities to EIA, cumulative impact assessment and precautionary requirements.
Monitoring, reporting and verification (MRV)	Determines whether carbon removal claims and environmental impacts can be credibly assessed.
Public consultation and stakeholder participation	Addresses procedural legitimacy and the inclusion of affected or relevant actors.
Allocation of responsibility	Clarifies who is responsible for data, monitoring, liability, supervision and possible corrective action.
Carbon accounting and certification	Links mCDR activities with climate policy instruments and possible carbon removal certification.
Transition from pilot to scale-up	Raises the question of when a research activity begins to require more demanding governance safeguards.
Transboundary and high-seas implications	Becomes relevant when activities may affect areas, actors or legal regimes beyond one national jurisdiction.

Table 5. Sensitive intervention points and their governance relevance

This phase was also shaped by the technique-family approach developed in D5.1. The deliverable emphasises that mCDR cannot be treated as one legally uniform category, because different methods engage different legal gateways, procedural requirements and accountability questions. This means that sensitive intervention points may look different for ocean alkalinity enhancement, biomass sinking, macroalgae cultivation or sub-seabed storage.

The selected intervention points were then connected to the emerging structure of D5.2. In particular, they correspond to the main building blocks of the multi-dimensional governance framework: legal and regulatory arrangements, ethical and social acceptability, scientific knowledge and uncertainty, economic incentives and risk-sharing, and institutional and multi-level governance.

The main result of Phase III was therefore a more targeted understanding of where stakeholder input is most useful. Rather than asking stakeholders about mCDR governance in general, the CPr could be oriented towards concrete governance choices: how activities are classified, how permits are granted, how monitoring is organised, how responsibilities are distributed, and how the move from research to possible deployment should be governed.

11.5 Phase IV: Specific engagement and knowledge consolidation

The fourth phase concerns the consolidation of knowledge with stakeholders who are relevant to the decision- and policy-making processes identified as sensitive intervention points. In line with the task description, this phase was facilitated mainly through Task 5.2 and Task 4.3, rather than through T5.1 alone.

Under **Task 5.2**, the CPr supported the preparation of D5.1 by enabling expert interviews, consultations and exchanges with actors working on legal, ethical, policy and geopolitical aspects of mCDR. D5.1 explicitly notes that the WP5 team synthesised findings from the subtasks together with collaborative inputs from Task 5.1, including expert knowledge obtained through semi-structured interviews. These inputs helped contextualise the analysis of existing legal frameworks, ethical considerations, decision-making processes and geopolitical implications of mCDR.

The first workshop, held in Warsaw on 29 May 2025, brought together nine participants from environmental and local organisations, think tanks, research and public institutions. The workshop in Rome, held on 12 December 2025, gathered nine participants representing public administration and environmental institutions, the business sector, and the academic and research community. The workshop in Madrid, held on 19 June 2026, brought together 10 participants representing public policy and governance; environment, marine science and ecological safeguards; and business, carbon markets and implementation. All three workshops explored OAE and macroalgae-based scenarios adapted to their respective national and marine contexts. These workshops created a direct link between stakeholder perception work in WP4 and the governance-oriented work of WP5.

The specific engagement activities focused on practical governance questions that corresponded to the sensitive intervention points identified in Phase III. These included, in particular:

Area of engagement	Issues discussed with stakeholders
Legal and regulatory frameworks	Legal classification, permitting, authorisation, applicable procedures
Risk and precaution	Environmental uncertainty, precautionary conditions, pilot acceptability
MRV and monitoring	Monitoring responsibilities, transparency, data access, verification
Stakeholder participation	Local communities, NGOs, public authorities, private-sector roles
Science-policy-business relations	Cooperation models, separation of roles, conflicts of interest
Scale-up and implementation	Conditions for moving from research or pilot activity to larger deployment
Transboundary governance	Allocation of responsibility, international coordination, high-seas or cross-border implications

Table 6. Areas of stakeholder engagement and issues discussed

The CPr was also broadened through cooperation with the sister project **UPTAKE**. SEAO2-CDR joined the UPTAKE online stakeholder forum (with 273 members), where a dedicated SEAO2-CDR subforum was established. This created an additional channel for communication with stakeholders, presentation of project results, feedback collection and sustaining engagement beyond individual interviews or workshops.

The main result of Phase IV was that the CPr became a functioning engagement infrastructure. It supported knowledge consolidation for D5.1, contributed stakeholder input to the development of D5.2, and strengthened the link between legal, ethical and policy analysis on the one hand, and stakeholder perceptions and practical governance concerns on the other. At the same time, the CPr should not be understood as a formal representative body or a substitute for public consultation. Its function was to provide structured expert and stakeholder input that could inform the project's governance framework.

11.6 Contribution of the CPr to D5.2

CPr contributes to D5.2 by linking the analytical work of WP5 with stakeholder knowledge and practical governance concerns. D5.2 builds on D5.1, which established the legal, ethical, political and geopolitical foundations for mCDR governance, and translates these findings into a broader multi-dimensional governance framework. The CPr supports this transition by helping to identify how governance issues appear in practice, how different actors understand them, and where further clarification or validation is needed.

More specifically, the CPr contributes to D5.2 in four ways:

Contribution	Relevance for D5.2
Stakeholder grounding	Ensures that the governance framework is informed by perspectives from research, policy, regulation, civil society and implementation contexts.
Identification of practical governance concerns	Helps clarify legitimacy, participation, monitoring, responsibility, transparency and conditions for responsible piloting.
Connection between WP4 and WP5	Links stakeholder perceptions and deliberative workshop findings with the legal, ethical and policy analysis developed in WP5.
Support for validation and uptake	Provides channels through which emerging findings and recommendations can be discussed, refined and communicated.

Table 7. Contributions of the Community of Practice to D5.2

In this sense, the CPr is not treated in D5.2 as a separate outreach activity, but as part of the methodological and practical basis of the governance framework. It supports the stakeholder-centred character of the model, particularly in relation to questions of participation, equity, legitimacy and co-creation, which are explicitly included in the structure of D5.2.

The contribution of the CPr is also important because D5.2 does not aim to propose a single uniform governance regime for all mCDR techniques. Instead, it develops a framework that is technology-specific, scale-sensitive, adaptive and multi-level. Stakeholder input gathered through the CPr helps make this framework more responsive to differences between techniques, institutional contexts and possible implementation pathways.

At the same time, the CPr has a limited and specific function. It does not replace formal public consultation, regulatory procedures or political decision-making. Its role is to provide structured expert and stakeholder input that can strengthen the practical relevance, legitimacy and usability of the D5.2 governance framework.

Phase	Main purpose	Status and progress	Main contribution to D5.2
Phase I Infrastructure development	Build the basic Community of Practice infrastructure	Completed or substantially completed	Stakeholder categories, mapping, engagement tools and procedures
Phase II Setting in motion	Activate the network and collect first inputs	Completed; follow-up exchanges continue	Expert and stakeholder input for D5.1 and early D5.2 work
Phase III Sensitive intervention points	Identify where stakeholder input matters most	Completed; refined through D5.1 and D5.2 development	Links between governance gaps, decision points and framework building blocks
Phase IV Specific engagement	Consolidate knowledge with relevant stakeholders	Ongoing through T5.2, T4.3 and UPTAKE	Validation, practical grounding and stakeholder-oriented refinement of D5.2

Table 8. Community of Practice progress across four phases

11.7 Conclusions

Task 5.1 has developed the Community of Practice from an initial stakeholder-mapping exercise into a functional engagement infrastructure for WP5. Across its four phases, the CPr network supported the identification of relevant actors, the collection of expert and stakeholder input, the selection of sensitive intervention points, and the consolidation of knowledge through interviews, consultations, workshops and the UPTAKE forum. Its main contribution to D5.2 is to strengthen the stakeholder-oriented and practice-sensitive character of the multi-dimensional mCDR governance framework. The CPr helps connect legal, ethical, political and geopolitical analysis with practical concerns about legitimacy, participation, monitoring, responsibility and conditions for responsible piloting.

At the same time, the CPr should be understood as a supporting mechanism, not as a formal decision-making body. Its role is to inform, test and refine the governance framework, and to provide a basis for further feedback, validation and dissemination in the final phase of the project.