

Scaling Nature-Based Carbon Dioxide Removal for a Net-Zero Future

Durable, science-based natural carbon removal is essential to closing the emissions gap for hard-to-abate sectors and can deliver economic and ecological value now.

A tipping point for carbon removal: As the window narrows to limit warming to 1.5°C, hard-to-abate sectors like aviation continue to grapple with the reality that decarbonization alone will not close the gap. Even with technological advances — whether sustainable fuels in aviation, carbon capture in cement production, or hydrogen in steel manufacturing — residual emissions will persist across these industries. Carbon dioxide removal (CDR) is no longer optional in a carbon management strategy, it is essential.

From trees to basalt: Expanding the carbon removal toolbox: Traditional nature-based approaches (e.g., forests, soils, wetlands) are vital, but land constraints, reversal risk, and MRV (monitoring, reporting, and verification) challenges mean they cannot remove all the residual carbon needed to meet the world's net-zero targets. This is where emerging nature-based CDR methods become essential additions to the toolbox:

- **Enhanced weathering (EW):** Lime or finely crushed silicate rock, such as basalt, is applied to croplands, capturing CO₂ while improving soil health. Projects like MATI Carbon in India and Tanzania use mining waste as feedstock, turning an industrial byproduct into a resource.
- **Marine CDR (mCDR):** Techniques like ocean alkalinity enhancement (OAE) accelerate the ocean's natural CO₂ uptake, locking away carbon for millennia while

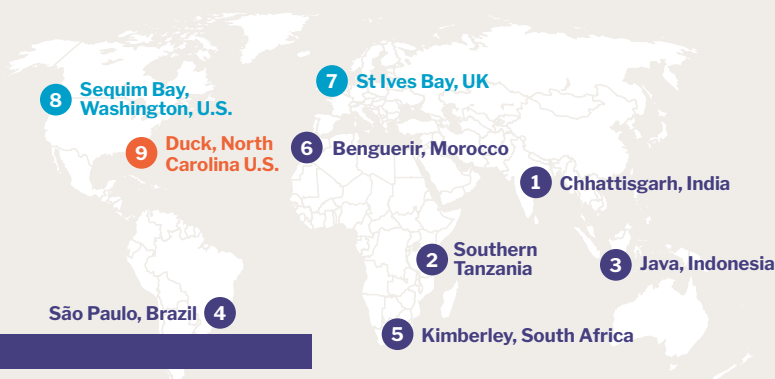
reversing acidification locally and supporting marine life. These methods have low land footprints and can integrate into existing industrial systems. RMI estimates that EW could remove 1 gigaton per year and mCDR 2-4 gigatons by 2100 if MRV improves. A new wave of nature-based CDR — including EW and mCDR methods, such as OAE — offers high durability and real-world co-benefits. Compared with capital-intensive engineered systems like direct air capture, these approaches can be deployed more rapidly by leveraging existing infrastructure from agriculture, mining, and coastal industries. Yet, cost, trust, and scaling challenges remain.

Driving costs down through better science: High-quality, durable CDR credits currently cost more than \$300 per ton, largely due to the expense of rigorous MRV. Though lower-cost credits based on more “traditional” CDR are available in the marketplace, the ceiling on scalability and reversal risk of these methods requires an additional class of innovative nature-based CDR approaches.

Scientific advances are key to breaking this cost barrier. Projects such as Mati Carbon's basalt applications, which recently won't the \$50M XPRIZE Carbon Removal, are helping to improve MRV accuracy, enhance credibility, and reduce cost. Tools such as in-field sensors, high-resolution geochemical models, and standardized registries are essential for verifying carbon removal at scale.

Potential Global Distribution and Cost Pathway for Nature-Based CDR

Nature-based carbon removal projects worldwide, from Brazilian basalt trials to ocean alkalinity pilots, show potential for scaling and cost reduction.



Enhanced weathering (land)

1 Mati Carbon

Project: Smallholder rice paddies
Status: Active deployment
Co-benefits: Yield gains; soil pH; smallholder income

2 Mati Carbon

Project: ERW soil rejuvenation
Status: Pilot phase
Co-benefits: Yield gains; drought resilience; farmer income

3 CIFOR-ICRAF and academic studies

Project: Volcanic ash/basalt on croplands
Status: Research potential
Co-benefits: Soil fertility; nutrient supply; potential SOC build

4 São Paulo State University

Project: Basalt on upland rice
Status: Research trials
Co-benefits: Soil fertility; rice yield; pH correction

5 Academic and industry consortia

Project: Mine tailings carbonation
Status: Feasibility stage
Co-benefits: Industrial byproduct reuse; mine rehab

6 OCP and research partners

Project: Mining waste valorization
Status: Feasibility studies
Co-benefits: Industrial byproduct reuse; land restoration

Marine carbon dioxide removal (ocean alkalinity enhancement)

7 Planetary Technologies with Plymouth Marine Lab

Project: Wastewater antacid addition
Status: Completed pilot
Co-benefits: Local de-acidification; MRV learnings

8 Ebb Carbon

Project: MCDR
Status: Scaling pilot
Co-benefits: De-acidification; electrochemical co-products

Marine enhanced rock weathering

9 Vesta

Project: Coastal carbon capture
Status: Field pilot
Co-benefits: Shoreline resilience; local de-acidification

Corporate buyers are also catalyzing the market. Frontier (Stripe, Shopify, McKinsey), Microsoft, and Amazon are paying premium prices today to accelerate both engineered and nature-based removal technologies, aiming to drive costs below \$100 per ton within a decade. This goal will rely on substantial investment, innovation, and a growing voluntary carbon market (estimated at \$50B by 2030).

Co-benefits beyond carbon: Nature-based CDR can generate climate, economic, and ecosystem value simultaneously. EW can boost yields, improve soil pH, and reduce fertilizer use, lowering costs for farmers while cutting nitrous oxide emissions. Selling carbon credits can provide a new income stream for rural communities. mCDR can enhance aquaculture and fisheries' productivity, purify water, and strengthen coastal economies. Integrating waste basalt from mining, or biochar from agricultural residues, turns industrial byproducts into carbon sinks — when feedstocks are vetted to avoid heavy-metal contamination — and supports a more circular economy.

Actions to hasten progress: Nature-based CDR is evolving into core climate infrastructure via integrated systems that deliver durable carbon removal alongside economic

resilience and ecosystem restoration. Scaling nature-based CDR will require coordinated action from industry, policymakers, and investors. Priority steps include:

- **Investing in trusted, science-based MRV systems** to ensure durability, comparability, and market credibility.
- **Pursuing first-of-a-kind pilots** and commercial-scale deployments in diverse geographies, mobilizing public-private finance for a broader funding base.
- **Integrating nature-based removals** into climate policy by:
 - Embedding high-durability CDR into national decarbonization strategies and NDCs;
 - Creating clear, science-based standards for credit quality and MRV;
 - Establishing cross-border credit recognition frameworks under Article 6 to link voluntary and compliance markets;
 - Offering targeted incentives (e.g., tax credits, subsidies) for projects that deliver verifiable co-benefits for rural and coastal communities.
- **Leveraging co-benefits** to position nature-based CDR as both a climate solution and an economic driver for rural and coastal communities.

With climate deadlines approaching, now is the time to back natural solutions that can deliver measurable results today and endure for generations.