

2. Carbon Capture – Environment

Oceans of Opportunity – Carbon Capture for Net-Zero India. India, the world's third-largest CO₂ emitter, is exploring ocean-based carbon capture techniques, like Ocean Alkalinity Enhancement and seaweed farming, to leverage its vast coastline. This strategy aims to create a significant carbon sink, helping India meet its 2070 net-zero target while addressing ecological and financial challenges.

Ocean-Based Carbon Capture for India's Net-Zero Goal

Core Strategy – Ocean-based carbon capture is presented as a critical strategy to assist India in achieving its net-zero target by 2070.

Dual Mission – This approach aims to transform India's seas into powerful engines that serve two purposes – facilitating large-scale carbon removal and promoting sustainable "blue growth" (ocean-based economic development).

Carbon Capture, Utilisation, and Storage (CCUS)

IEA Definition – The International Energy Agency (IEA) defines CCUS as a comprehensive group of technologies.

Step 1 – Capture – The process begins with capturing Carbon Dioxide (CO₂) emissions directly from large, stationary sources. These sources include –

1. Fossil fuel-based power plants
2. Other major industrial facilities

Step 2 – Transport – After capture, the CO₂ is transported from the source to a designated site.

Step 3 – Utilisation or Storage – The transported CO₂ has two primary destinations –

Utilisation – It can be used as a feedstock in various applications (e.g., manufacturing, biofuels).

Storage (Sequestration) – It can be injected into deep geological formations or depleted oil & gas fields for permanent storage and trapping, preventing it from entering the atmosphere.

India's Emission Reductions Commitments

Guiding Missions – India's climate action is guided by key national initiatives, including the LiFE mission (Lifestyle for Environment) and its updated NDCs (Nationally Determined Contributions) submitted under the Paris Agreement.

Pledges in the Updated NDC 2022 –

1. **Emissions Intensity** – To achieve a 45% reduction in the emissions intensity of its GDP (the amount of CO₂ per unit of GDP) by 2030, compared to 2005 levels.
2. **Electricity Capacity** – To ensure that 50% of its total installed electricity capacity will come from non-fossil fuel sources by 2030.
3. **Carbon Sink** – To create an additional carbon sink equivalent to 2.5 to 3 billion tonnes of CO₂ (GtCO₂e) by expanding its forests and tree cover.

Ocean-based Negative Emission Techniques

1. Ocean Alkalinity Enhancement (OAE)

Mechanism – This process involves the addition of alkaline minerals, such as lime or olivine, to seawater.

Effect – It increases the seawater's natural chemical ability to absorb and lock away atmospheric CO₂.

Key Benefit – OAE provides a highly stable and durable form of carbon storage, estimated to last for over 100,000 years.

2. Biological Carbon Capture

Mechanism – This method leverages natural marine life that absorbs CO₂ through the process of photosynthesis.

Key Organisms – This includes phytoplankton, seaweed, and microalgae.

3. Ocean Fertilisation

Mechanism – This technique promotes the growth of phytoplankton in specific ocean regions that are rich in macronutrients but deficient in micronutrients.

Process – This is achieved by adding the required micronutrients, such as iron, phosphorus, or nitrogen.

Goal – The resulting phytoplankton bloom absorbs CO₂, and when the organisms die, they sink,

facilitating long-term carbon storage in the deep ocean.

4. Marine Protected Areas (MPAs)

Definition – These areas, which include critical ecosystems like coral reefs and mangroves, currently cover 8.3% of the ocean.

Role – They are vital for maintaining overall ocean health and biodiversity.

Mangrove Potential – Mangroves are exceptionally effective carbon sinks, capable of storing up to 1,000 tonnes of carbon per hectare.

India's Potential for Ocean-Based CCUS

Emissions Context – India is the world's third-largest CO₂ emitter (after the US and China), with 2.6 gigatonnes of annual emissions, making carbon capture a national priority.

Geographic Advantage – India's vast marine resources provide a massive opportunity.

Coastline – 11,098.8 km

Exclusive Economic Zone (EEZ) – 2 million sq. km

Specific Opportunities –

Seaweed Farming – It is estimated that cultivating seaweed over just 20% of India's ocean area could potentially remove 0.6–1 gigatonne of CO₂ annually.

OAE + Aquaculture – Combining Ocean Alkalinity Enhancement (OAE) with aquaculture practices can create a synergistic effect, providing durable carbon storage while simultaneously enhancing marine productivity.

Circular Carbon Economy – Captured carbon can be repurposed as a valuable resource for –

1. Biofuels
2. Pharmaceuticals
3. Green hydrogen
4. Fertilizers
5. Biopolymers
6. Construction materials

Economic Vision – This approach promotes the development of circular carbon economies and accelerates blue growth.

Challenges

Ecological Concerns – Altering Ocean chemistry (e.g., through OAE) or changing the nutrient balance (through fertilization) could have unforeseen negative impacts on marine biodiversity.

Regulatory Gaps – India currently lacks comprehensive marine carbon governance frameworks and regulations to manage these new technologies and their potential environmental effects.

High Capital Costs – As these are early-stage technologies, ocean CCUS projects require significant long-term funding and effective risk mitigation strategies to become commercially viable.

Way Ahead – A Strategic Roadmap

Policy Integration – Ocean-based CCUS strategies must be formally embedded within India's National Carbon Capture Policy and integrated into the Blue Economy Mission.

Research and Development (R&D) – India should establish pilot projects under the Deep Ocean Mission to specifically test, verify, and scale up techniques like ocean alkalinity enhancement and biological carbon farming.

Private Sector Mobilisation – To attract investment, the government should provide fiscal incentives and develop carbon credit markets for blue carbon restoration (e.g., mangroves) and for marine CDR (Carbon Dioxide Removal) startups.

International Collaboration – India should actively partner with global CCUS hubs in countries like Japan, Norway, and the EU to facilitate crucial technology transfer and share knowledge.

Source – <https://www.orfonline.org/expert-speak/oceans-of-opportunity-carbon-capture-for-net-zero-india#~:text=Leveraging%20India's%20Potential%20for%20Ocean-based%20Carbon%20Capture,for%20Net%20Zero>