

## Carbon Sequestration Techniques for Climate Change Mitigation

Dequan Hao\*

Department of Forest Research, Shandong University, Jinan, Shandong, China

### DESCRIPTION

Climate change, driven largely by anthropogenic emissions of Greenhouse Gases (GHGs) such as Carbon Dioxide (CO<sub>2</sub>), poses significant challenges to global ecosystems and human societies. As efforts intensify to reduce emissions, carbon sequestration—removing CO<sub>2</sub> from the atmosphere and storing it long-term—has emerged as a critical strategy for mitigating climate change. This article describes various carbon sequestration techniques, their effectiveness, and their potential roles in achieving climate goals. Carbon dioxide, primarily from fossil fuel combustion, deforestation, and land-use changes, is the leading GHG contributing to global warming. To limit global temperature rise and its associated impacts, it is essential not only to reduce emissions but also to actively remove CO<sub>2</sub> from the atmosphere. Carbon sequestration refers to the process of capturing and storing carbon dioxide, thereby preventing its release into the atmosphere where it contributes to climate change.

### Natural carbon sequestration processes

**Forests and afforestation:** Forests play a important role in carbon sequestration through photosynthesis, which converts CO<sub>2</sub> into biomass. Afforestation and reforestation efforts aim to increase forest cover and enhance carbon sinks. Mature forests can sequester significant amounts of carbon dioxide annually, making forest conservation and restoration key strategies in natural climate solutions.

**Soil carbon sequestration:** Healthy soils store substantial amounts of carbon in organic matter. Agricultural practices such as no-till farming, cover cropping, and agroforestry enhance soil carbon storage by promoting the accumulation of organic matter and reducing soil disturbance. Soil carbon sequestration not only mitigates climate change but also improves soil fertility and water retention.

### Technological carbon sequestration techniques

**Direct Air Capture (DAC):** DAC technologies capture CO<sub>2</sub> directly from the atmosphere using chemical processes. Captured CO<sub>2</sub> can be stored underground or utilized in industrial

processes such as synthetic fuel production. DAC offers potential for scalable carbon removal but currently faces challenges related to cost and energy requirements.

**Carbon Capture and Storage (CCS):** CCS involves capturing CO<sub>2</sub> emissions from industrial sources such as power plants and storing it permanently underground in geological formations. CCS technologies are already in use at several large-scale facilities worldwide, demonstrating feasibility in reducing emissions from industrial sources. Challenges include infrastructure costs and public acceptance.

### Biological carbon sequestration techniques

**Oceanic carbon sequestration:** Marine ecosystems, particularly phytoplankton and oceanic vegetation, play a important role in carbon sequestration through photosynthesis and organic carbon burial. Enhancing oceanic carbon sinks through conservation and restoration of coastal habitats and marine vegetation can mitigate CO<sub>2</sub> levels in the atmosphere.

**Blue carbon:** Coastal ecosystems such as mangroves, salt marshes, and seagrasses—collectively known as blue carbon ecosystems—sequester carbon dioxide at rates higher than terrestrial forests. Protecting and restoring these ecosystems not only enhances carbon storage but also provides valuable coastal protection and supports biodiversity.

### Policy and economic considerations

**Carbon pricing and incentives:** Implementing carbon pricing mechanisms such as carbon taxes or cap-and-trade systems incentivizes industries to reduce emissions and invest in carbon sequestration technologies. These economic instruments can drive innovation and accelerate the deployment of carbon sequestration solutions.

**International agreements and funding:** Global agreements like the Paris agreement outline commitments to reduce GHG emissions and enhance carbon sequestration efforts. International funding mechanisms support developing countries in implementing climate-resilient strategies and technologies, including carbon sequestration projects.

**Correspondence to:** Dequan Hao, Department of Forest Research, Shandong University, Jinan, Shandong, China, E-mail: hdq56@nwafu.edu.cn

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## Challenges and future directions

**Technological advancements:** Continued research and development are essential to overcoming technological barriers and reducing costs associated with carbon sequestration techniques such as DAC and CCS. Innovation in materials science and engineering could lead to more efficient and economically viable carbon capture and storage solutions.

**Environmental and social impacts:** The deployment of carbon sequestration technologies must consider potential environmental impacts, such as land-use change and water use, as well as social implications for local communities. Ensuring equitable distribution of benefits and addressing concerns about land rights and ecosystem integrity are essential for sustainable implementation.

## CONCLUSION

Carbon sequestration techniques represent powerful tools in the fight against climate change, offering pathways to achieve net-zero emissions and limit global temperature rise. From natural processes like afforestation and soil management to technological advancements in DAC and CCS, a diverse array of strategies exists to enhance carbon sinks and mitigate CO<sub>2</sub> levels in the atmosphere. Effective implementation will require concerted efforts across sectors, supported by robust policies, international cooperation, and continued innovation.