Carbon Capture and Storage

For Prelims: Global Energy & Carbon Dioxide Emissions, Carbon Storage, Global warming, **Climate change**, National Centre of Excellence in Carbon Capture and Utilization Mumbai, **Afforestation**, **Paris Agreement.**

For Mains: Approaches to Carbon Capture and Storage and Related Challenges.

Source: Reuters

Why in News?

The UK government has reasserted its commitment to **advancing projects aimed at capturing and storing** carbon dioxide (CO_2) emissions as a crucial component of its strategy to achieve net-zero emissions.

What is Carbon Capture and Storage (CCS)?

- **About:**
  - It is a process designed to **mitigate the emissions of carbon dioxide (CO_2)** generated from industrial processes and the burning of fossil fuels, particularly in power plants.
  - The goal of CCS is to prevent a significant amount of CO_2 from entering the atmosphere and contributing to global warming **and** climate change.
- **Approaches:** Carbon capture and storage (CCS) encompasses two primary approaches:
  - The **first method** is known as **point-source CCS,** which involves capturing CO2 directly at the site of its production, such as industrial smokestacks.
  - The **second method, direct air capture (DAC),** focuses on removing CO2 that has already been emitted into the atmosphere.
  - The recent UK initiatives **specifically target point-source CCS.**
- **Mechanisms of Point Source- CCS**: The process of carbon capture and storage encompasses several distinct steps, each contributing to the effective containment of CO_2 emissions:
  - **Capture:** CO_2 is **isolated from other gases** generated during industrial processes or power generation.
  - **Compression and Transportation:** Once captured, CO_2 is compressed and transported to designated storage sites, frequently through pipelines.
  - **Injection:** The CO_2 is then injected into subterranean rock formations, often situated at depths of one kilometer or more, **where it remains stored for extended periods, sometimes lasting decades.**
- **Applications:**
  - **Mineralization:** Captured carbon can be reacted with **certain minerals to form stable carbonates**, which can be stored safely underground or used in construction materials.
    - This process, known as **mineral carbonation, offers a long-term and secure method of carbon storage.**
  - **Synthetic Fuels**: Captured CO_2 can be combined with hydrogen (often produced via electrolysis using renewable energy) **to produce synthetic fuels such as synthetic**

natural gas, synthetic diesel, or even synthetic jet fuel.
    - **Greenhouses and Indoor Agriculture:** Captured carbon dioxide can be supplied to greenhouses and indoor farming facilities to enhance plant growth.
    - **Dry Ice Production:** Captured carbon dioxide can be used to produce dry ice, which is **solid carbon dioxide at extremely low temperatures.**
        - Dry ice has various applications, including **shipping and transportation of perishable goods, medical and scientific purposes,** and special effects in the entertainment industry.

Note:

- In India, two National Centres of Excellence in Carbon Capture and Utilization are being established.
    - **National Centre of Excellence in Carbon Capture and Utilization (NCoE-CCU) at Indian Institute of Technology (IIT) Bombay**, Mumbai
    - **National Centre in Carbon Capture and Utilization (NCCCU)** at **Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru.**

- **Challenges:**
    - **Cost and Economics:** CCS involves **high initial capital costs** for building capture, transportation, and storage infrastructure.
        - The cost of capturing CO_2 from **flue gases** or industrial processes can be significant, affecting the overall viability of CCS projects.
    - **Geological Storage Suitability:** Identifying and securing suitable geological formations for long-term CO_2 storage is a challenge.
        - Not all geological formations are appropriate for CO_2 storage **due to potential risks of leakage or** seismic activity.
    - **Extended Lifespan of Fossil Fuel Companies**: Certain environmental organizations raise concerns regarding the effectiveness of CSS, suggesting that its implementation might **unintentionally prolong the operational viability of fossil fuel companies.**
        - This potential consequence could inadvertently **hinder the speed of transitioning to more sustainable and** cleaner energy sources.

Way Forward

- **Natural Climate Solutions Integration:** Combining CCS with natural climate solutions can enhance its effectiveness.
    - Embracing initiatives like **reforestation,** afforestation**, and sustainable land management can complement CCS** efforts by sequestering carbon **naturally,** promoting biodiversity, and enhancing ecosystem resilience.
- **International Collaboration and Knowledge Sharing:** To address global climate challenges, countries must collaborate and share knowledge and expertise in CCS.
    - Establishing **international forums, research partnerships, and technology-sharing initiatives** can accelerate the development and adoption of innovative carbon capture solutions.
- **Balancing CCS and Emission Reduction for Climate Action:** The **United Nations** report underscores CCS's potential to align with the **Paris Agreement'**s market-based mechanisms like carbon trading through carbon credits.
    - However, it emphasizes that emission prevention remains paramount. An **inclusive climate strategy mandates both carbon capture technology adoption and proactive** emission reduction to effectively address climate change.
        - In line, in terms of **Nationally Determined Contribution**, India now stands committed to reduce **Emissions Intensity of its GDP by 45% by 2030.**

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims

Q1. Consider the following agricultural practices: (2012)

1. Contour bunding
2. Relay cropping
3. Zero tillage

In the context of global climate change, which of the above helps/help in carbon sequestration/storage in the soil?

(a) 1 and 2 only
(b) 3 only
(c) 1, 2 and 3
(d) None of them

Ans: (b)

Q2. In the context of mitigating the impending global warming due to anthropogenic emissions of carbon dioxide, which of the following can be the potential sites for carbon sequestration? (2017)

1. Abandoned and uneconomic coal seams
2. Depleted oil and gas reservoirs
3. Subterranean deep saline formations

Select the correct answer using the code given below:

(a) 1 and 2 only
(b) 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans: (d)

Q3. What is/are the advantage/advantages of zero tillage in agriculture? (2020)

1. Sowing of wheat is possible without burning the residue of previous crop.
2. Without the need for nursery of rice saplings, direct planting of paddy seeds in the wet soil is possible.
3. Carbon sequestration in the soil is possible.

Select the correct answer using the code given below:

(a) 1 and 2 only
(b) 2 and 3 only
(c) 3 only
(d) 1, 2 and 3

Ans: (d)