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Carbon Sequestration and Trading - An Overview

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Abstract

Carbon is an essential element for crop growth and development. It exists in the form of CO_2 in the atmosphere. It is the primary greenhouse gas (GHG) emitted due to anthropogenic activities and biological processes. Burning of fossil fuels such as coal, natural gas and oil, agricultural activities, land use changes and other natural processes are leading to the accumulation of CO_2, methane, nitrous oxide and halocarbons, above threshold levels in the atmosphere. It has been linked to climate change and it's associated consequences. These are inturn affecting the lives of human beings and other forms of life on the earth. Now, the whole scientific community is looking at carbon sequestration and carbon trading as the two most important approaches to tackle climate change, as they play a pivotal role in reducing the CO_2 levels in the atmosphere either directly or indirectly.

1. Introduction

Continuous stockpiling of CO_2 in the atmosphere (Figure 1) is a matter of great concern, as it can escalate the problem of climate change. The global average temperature in 2022 is estimated to be about 1.15°C above the 1850-1900 average (Anonymous, 2022a). To restrict global warming to 1.5°C, as per the Paris Agreement, there is a need to reduce current GHG emission levels to "net zero" by 2050. Carbon sequestration and carbon trading can play a crucial role in the coming years to reduce atmospheric carbon to the desired levels by reclaiming the imbalances occurring in carbon cycle.

2. Carbon Dioxide

A greenhouse gas is a gas that allows sunlight to pass through the atmosphere, but, prevent the heat going back/from leaving the atmosphere and causes climate change by warming up the earth. CO_2 is the primary gas, accounting for about 76% of GHG emissions (Figure 2). The CO_2 level has been steadily rising since the beginning (280 ppm) of Industrial revolution (IRN) and reached 414.57 ppm (parts per million) by November 2022 (Anonymous, 2022b). Since IRN, humans have generated 1.5 trillion tons of

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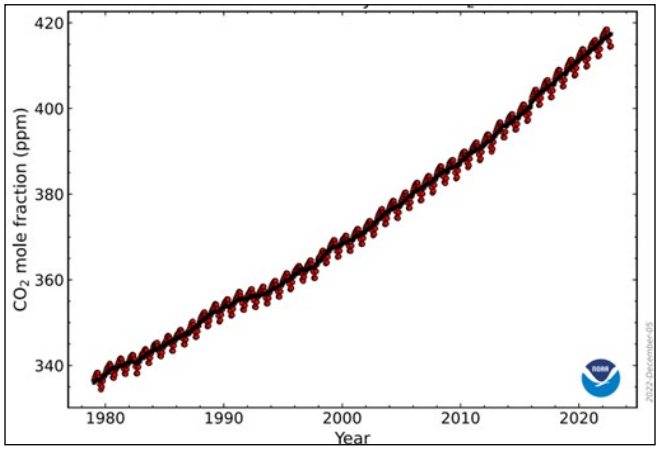

Figure 1: Trend of CO_2 levels at global level (Anonymous, 2022a)

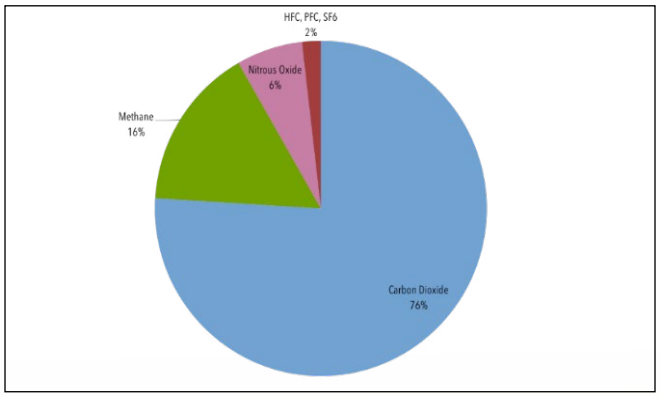

Figure 2: Global manmade greenhouse gas emissions by gas,2015 (www.c2es.org/content/international-emissions)

CO_2 pollution, much of which will continue to warm the atmosphere for thousands of years.

Ever growing population and increase in consumption levels, living standards, energy consumption, burning of fossil fuels, deforestation, industrial processes, agricultural activities, vehicles, aeroplanes, ships, waste disposal lobbying problems and lack of education can be attributed to increasing CO_2 levels. Historical and projected levels of GHG emissions by major nations is shown in Figure 3.

Hotter temperatures, melting of glaciers, rising of sea levels, floods, erratic rainfall distribution, incidence of drought, loss of biodiversity, shifting in plant flowering times, pests and weeds invasions and wildfire threats etc., will be the consequences of CO_2 led climate change.

3. Carbon Sequestration (CS)

CS is the process of capturing or trapping CO_2 and storing the same in soil carbon pool (Figure 4). It is one of the methods of reducing the CO_2 levels in the atmosphere. This process is predominantly mediated by bio-chemical processes like photosynthesis, which can store the carbon in the form of soil organic carbon (SOC). It may also occur in dry and semi-arid regions by the conversion of CO_2 into inorganic forms such as secondary carbonates in the soil, but at a very lower rate.

3.1. Types of Carbon Sequestration

3.1.1. Terrestrial Carbon Sequestration

It is the process through which CO_2 from the atmosphere

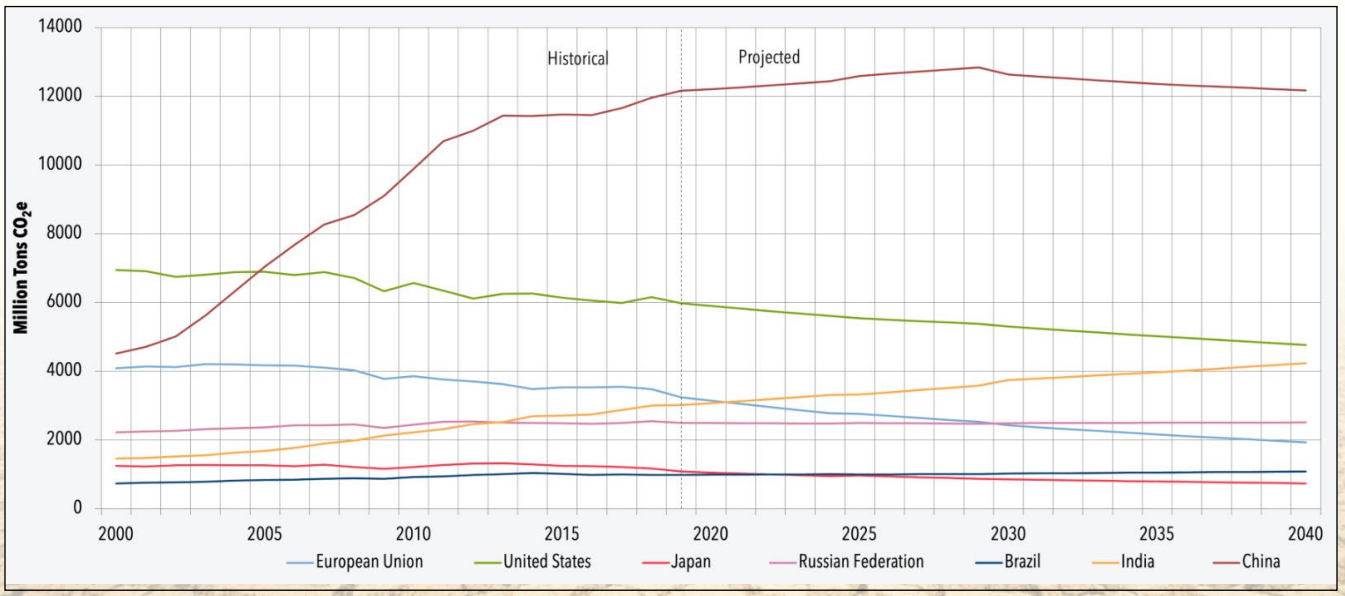

Figure 3: Greenhouse gas emissions for major economies, 2000–2040 (www.c2es.org/content/international-emissions)

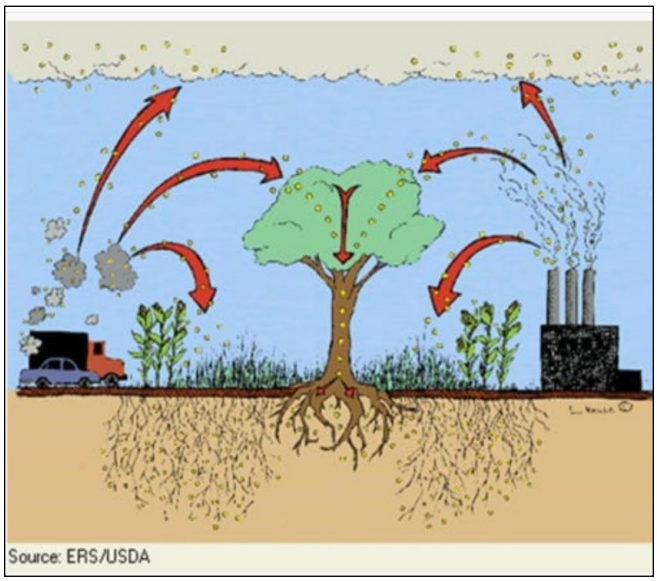

Figure 4: Carbon sequestration (www.ecolandscaping.org/wp-content/uploads/2018/01/Photo1.jpg)

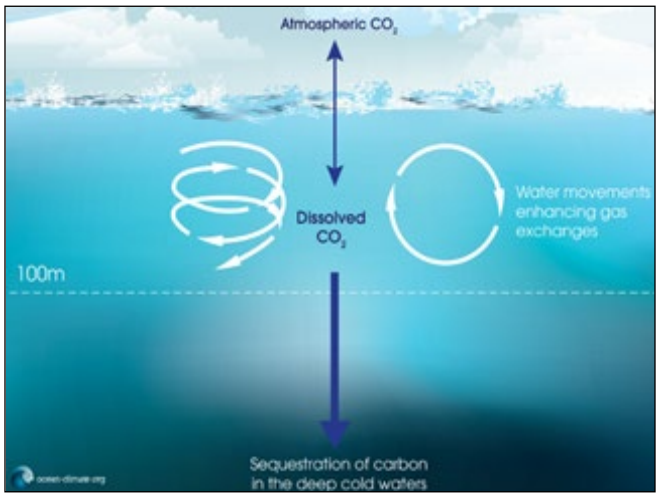

Figure 5: Oceanic carbon sequestration (www.ocean-climate.org)

is absorbed by trees and plants through photosynthesis and stored as carbon in soils and biomass (tree trunks, branches, foliage, and roots).

3.1.2. Geologic Carbon Sequestration

It is the process of storing CO_2 in underground geologic formations including oil reservoirs, gas reservoirs, non-mineable coal seams, saline formations and shale formations with high organic content. Typically, carbon dioxide is captured from industrial sources and injected into porous rocks for long-term storage.

3.1.3. Oceanic Carbon Sequestration

The Ocean is a large natural carbon sink, it can absorb and store large amounts of CO_2 from the atmosphere (Figure 5). This can be done by enhancing productivity of ocean biological systems through Fe fertilization and injecting CO_2 into the deep ocean. The dumping of iron stimulates phytoplankton production, which in turn leads to enhanced photosynthesis from these microorganisms, helping in CO_2 absorption.

3.2. Methods of Carbon Sequestration

3.2.1. Natural Carbon Sequestration

It is the process by which nature has achieved a balance of CO_2 in our atmosphere suitable for sustaining life. Animals expel CO_2, as do plants during the night. Nature provided trees, the oceans, earth and the animals themselves as carbon sinks or sponges. All organic life on this planet is carbon based and when plants and animals die, much of the carbon goes back into the ground where it has little impact on contributing to global warming.

3.2.2. Artificial Carbon Sequestration

It refers to several processes by which carbon emissions are captured at the point of production (e.g., factory chimneys) and then buried such as geologic sequestration, ocean sequestration etc. One proposed method is ocean sequestration whereby carbon dioxide is injected deep into the ocean, forming lakes of CO_2 as it will stay down deep due to the pressure and temperature of the surrounding water, gradually dissolving into that water over time. Though lack of technology, high cost and environmental concerns are the challenges, faster sequestration, high productivity and employment generation will be the potentials.

3.3. Crop Management Practices for Improving Carbon Sequestration in Soil

Different agronomic practices for soil carbon sequestration are furnished in the Figure 6. The crop management practices which can be recommended in the place of traditional practices are mentioned in the Table 1.

3.4. Impacts of Carbon Sequestration

CO_2 capture and storage are most applicable to agriculture, forests and large centralized sources like power plants and industries. Capture technologies also open the way for large-scale production of low-carbon or carbon-free electricity and fuels. Globally, the total

Figure 6: Agronomic practices for improving SOC sequestration

amount of carbon in vegetation, soil and detritus is roughly 2,200 billion tons and it is estimated that the amount of carbon sequestered annually by terrestrial ecosystems is approximately 2.6 billion tons only. The amount of carbon found just under the surface of oceans is roughly 920 billion tons, which exceeds the amount in the atmosphere (about 760 gigatons). Of the carbon emitted to the atmosphere by human activities, only 45% stays in the atmosphere and the rest is captured by natural processes. Around 25% of carbon has been historically captured by the forests, grasslands and agricultural lands. Global carbon pools are detailed in Table 2.

4. Carbon Trading

Carbon can be traded in the form of credits/offsets (1 carbon credit = 1 Metric tonne of CO_2 equivalent). Act of buying and selling of carbon credits is called carbon trading or carbon emission trading or Cap and trade system (CAT). It is a market driven system aimed at providing economic incentives to encourage organizations to reduce their carbon footprint

- It is a policy instrument of choice among the governments of countries
- It works by setting a quantitative limit or cap by the governments or intergovernmental panels on the emissions produced across the industries or whole economy
- Emissions trading, as set out in Article 17 of the

Table 1: Comparison between traditional and recommended management practices in relation to soil organic carbon sequestration (Lal, 2004)

Traditional methods	Recommended management practices
❖ Biomass burning and residue removal	❖ Residue returned as surface mulch
❖ Conventional tillage and clean cultivation	❖ Conservation tillage, no tillage and mulch farming
❖ Bare/idle fallow	❖ Growing cover crops during the off season
❖Continuous monoculture	❖ Crop rotations with high diversity
❖ Low input subsistence farming and soil fertility mining	❖ Judicious use of off farm input
❖ Intensive use of chemical fertilizers	❖ Integrated nutrient management with compost, biosolids and nutrient cycling, precision farming
❖ Intensive cropping	❖ Integrating trees and livestock with crop production
❖ Surface flood irrigation	❖ Drip, furrow or sub irrigation
❖ Indiscriminate use of pesticides	❖ Integrated pest management
❖ Cultivating marginal soils	❖ Conservation reserve program, restoration of degraded soils through land use change

Table 2: Global carbon pools (Lal, 2004)

S. No.	Reservoirs of carbon	Carbon pool (Pg)
1.	Oceanic pool	38,000
2.	Geologic pool	5,000
3.	Soil carbon pool	2,300
4.	Atmospheric pool	770
5.	Biotic pool	560
6.	Total	46,820

Kyoto Protocol, allows countries that have emission units to spare, emissions permitted them but not "used" and to sell this excess capacity to countries that are over their targets.

➢ By paying someone else to either reduce their emissions or capture their carbon, companies can compensate for their environmental footprint and even, in the most ambitious cases, use carbon credits to get to carbon-neutral status

➢ Several emission trading schemes (ETSs) are operating across the world in which, European union emissions trading scheme (EU ETS) is the largest and the most ambitious carbon trading scheme

4.1. Advantages and Disadvantages of Carbon Trading

✓ It limits the greenhouse gas emissions over the years by capping policy

✓ It can be source of revenue, especially for developing nations

✓ It supports free market system

✓ Encourages the industries to look for innovative approaches

✓ Right to pollute: Industries in the ratified nations can purchase the legal rights to pollute the atmosphere.

✓ Many industries of the developed nations are opting for purchasing of more allowances instead of implementing greener technologies

✓ No effective carbon reduction in the atmosphere as it leads to carbon reduction in one place results in carbon emission in some other place

5. Current Scenario of India

India is the fifth most vulnerable country to the climate change and third largest emitter of GHGs, with 74% of its carbon emissions attributable to methane from livestock and cultivation and another 17.5% of agricultural carbon emissions derived from rice cultivation. Every year in northern India, 23 million tonnes of paddy stubble is burned, contributing as much as 40% of New Delhi's pollution during winter months (Anonymous, 2022c). However, per capita emissions are very low, 1.91 tonnes against 4.79 tonnes at global level. As of now India has decided not to export carbon credits, until it meets the commitments made at COP21 and COP26.

➢ *Towards Net zero:* India has pledged to be carbon neutral (Net zero carbon emissions) economy by 2070 and in view of that, many regenerative and eco-friendly agricultural practices like crop residue management, afforestation and reforestation with digital tools are topmost priorities. Yet, carbon verification and validation processes with integrated approaches are under the pipeline.

6. Conclusion and Future Line of Work

Countries in the world are united to combat against climate change and to reduce carbon footprint. The soils and forests can be large CO_2 sinks. The improved agricultural practices, agroforestry, reforestation, afforestation and forest-related mitigation activities have great contribution towards carbon sequestration relatively at cheaper cost. Ultimately, there should be mechanism to benefit farmers who are adopting pro environmental agronomic practices.

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