

## Carbon Farming: A Win-Win for Farmers and the Planet

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### Abstract:

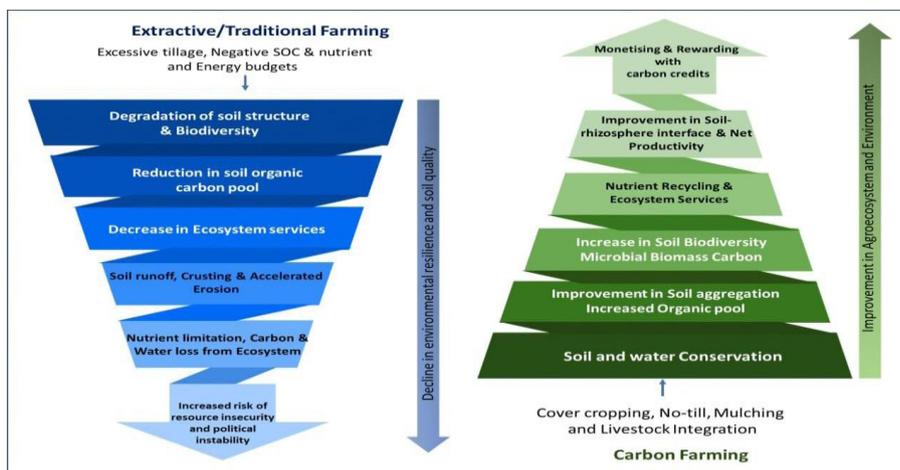
This article provides a comprehensive analysis of how carbon farming decreases atmospheric CO<sub>2</sub> concentrations by increasing carbon stocks in soil. Carbon farming reduces global warming and improves agricultural sustainability through various techniques, including carbon sequestration, agroforestry, intercropping, cover crops, reduced fertilizer application, livestock management, reduced tillage, using organic mulch, working with biochar, etc. Carbon farming is a farm-based solution to climate change that provides revenue to farmers for shifting to soil carbon sequestration farming techniques. It is a process that involves monitoring, reporting, and verification to generate carbon credits and sold to organizations looking to offset their greenhouse gas emissions. By storing carbon in soil, farmers can earn additional income by carbon trading, reduce production costs, and build sustainable farming system, thus making carbon farming as a promising revenue stream for farmers. The article discusses the carbon farming initiatives and emission reduction projects and schemes, challenges such as farmer awareness, market instability etc. and future directions to enhance carbon farming in India.

### Introduction:

Carbon Farming refers to sustainable agricultural practices that aims to increase the storage of carbon in biomass/ trees and soil while reducing greenhouse gas emissions. Carbon farming aims at maximizing carbon sequestration through:

- (a) Geological sequestration i.e. storing anthropogenic CO<sub>2</sub> deep underground in geological formations to prevent it from entering the atmosphere,
- (b) Oceanic sequestration i.e. storing carbon in the oceans either through biological pump that involves marine organisms, phytoplankton absorb CO<sub>2</sub> during photosynthesis and after their death, they sink taking carbon to deeper ocean layers or through physical pump that involves CO<sub>2</sub> dissolved in cold deeper ocean water and is transported by ocean currents.
- (c) Terrestrial sequestration i.e. storing carbon in forests, soils, and vegetation. It mainly occurs through photosynthesis, whereby plants absorb CO<sub>2</sub> and convert it into organic carbon compounds.

Carbon farming is also known as “Regenerative Agriculture” because it restores soil health and fertility by increasing soil organic matter, reverses environment degradation, mitigates climate change and enhances ecosystem services. Carbon farming provides economic incentives to farmers through carbon trading. Carbon can be traded in the form of credits (1 carbon credit = 1 Metric ton of CO<sub>2</sub> equivalents). The act of buying and selling of carbon credits is called carbon trading or Cap and Trade system (CAT).



### Techniques for Carbon Farming:

- **Agroforestry:** The integration of trees with agriculture is called Agroforestry. It contributes climate change mitigation through carbon sequestration and is an important component of carbon farming. Agroforestry sequesters carbon by storing carbon in above ground (trees, shrubs, and crops) and below ground biomass (roots and soil organic matter). Trees within agroforestry systems uptake atmospheric CO<sub>2</sub> during photosynthesis and store it in their leaves, branches, and trunks. Tree leaves, twigs and organic residues fall to the ground and enrich the soil organic content. As they break down over time, they release carbon into the ground, which goes towards long-term carbon storage. Agroforestry also provides an additional source of income to farmers.
- **Cover Crops:** Cover crops play a vital role in carbon farming by acting as a link between atmospheric CO<sub>2</sub> and long-term soil carbon storage. When these crops are grown between main crop cycles, they capture CO<sub>2</sub> through photosynthesis and store it in their roots, stems, and leaves. When incorporated into soil, organic matter increases and fertility is enhanced. Deep-rooted species are particularly effective as they deposit carbon deeper into the soil making it less prone to decomposition. Moreover, cover crops protect existing soil carbon by forming a protective layer that protects the soil from erosion.
- **Zero-Tillage:** Frequent and heavy tilling increases the rate of CO<sub>2</sub> release from the soil and breaks up soil structure which reduces the productivity of the soil. Zero tillage eliminates ploughing operations, reducing CO<sub>2</sub> emissions from machinery. Moreover, soil aggregates remain stable and trap organic carbon within, physically protecting it from microbial attack.
- **Biochar application:** Biochar is produced through pyrolysis. During this process, a large portion of the carbon in the biomass is converted into stable aromatic carbon rings. Unlike the crop residues or manure that decompose quickly and release CO<sub>2</sub>, biochar is highly resistant to microbial breakdown. It can remain in soil for hundreds and thousands of years, effectively locking carbon in soil.
- **Terra-Preta:** Terra Preta (meaning “black earth” in Portuguese) is an ancient biochar-based soil management technique. It is made by adding charcoal (biochar), food waste, manure, bones and organic residues into nutrient-poor tropical soil. The charcoal (biochar) in Terra Preta is highly stable and locks carbon in soil for centuries.

- **Rotational grazing:** It involves periodically relocating livestock to new pastures, this practice prevents overgrazing and allows previously grazed land to rejuvenate and grow deeper root systems. These roots deposit soil organic matter which increases soil organic carbon over time. This practice prevents soil erosion, increases water retention and overall ecosystem resilience, making it a key strategy in regenerative agriculture.
- **Reduced fertilizer application:** Chemical fertilizers reduce the capacity of soil to sequester carbon and significantly cuts greenhouse gas emissions which are released during the manufacturing of fertilizers. Organic manures and cover crops are used for nutrient management in place of these fertilizers which reduces the cost of cultivation and makes farming sustainable and profitable.
- **Integrating Silvi-pastoral systems:** Integrating trees with livestock increases carbon stocks both above and below ground. It provides shade and fodder for animals besides maintaining soil health and climate resilience.



### Significance of Carbon Farming:

- **Climate Change Mitigation:** Carbon farming is one of the powerful weapons to fight climate change by reducing Greenhouse gas emission by sequestering atmospheric CO<sub>2</sub> in soil and biomass turning agriculture farms from emitters to sink of carbon. Key practices such as agroforestry, conservation tillage, biochar application and improved crop and livestock management help in achieving this.
- **Soil Health Enhancement:** Carbon Farming boosts soil health by increasing soil organic matter and water retention capacity of soil. In addition to this it also reduces soil erosion resulting in amplified crop yields and agricultural productivity.
- **Biodiversity Enrichment:** Carbon farming enhances biodiversity by safeguarding beneficial microbes in soil, attracting beneficial insects and pollinators that enhances crop health and reduces dependency on pesticides.
- **Economic opportunities:** Carbon farming practices offers significant economic opportunities by

allowing farmers to earn income from carbon credits and reduces input costs (fertilizers, diesel).

The emerging carbon economy creates jobs in data tracking, verification, and project development.

India's carbon stock has reached 30.43 billion tons of CO<sub>2</sub> equivalent, indicating that the country has already achieved 2.29 billion tons of additional carbon sequestration compared to the 2005 baseline, approaching its target of

2.5 to 3 billion tons by 2030.



#### Policies and Institutional support:

- **National action plan on climate change:** NAPCC was released by the Prime Minister on June 30, 2008 focusses on national strategy to enable country to adapt to climate change and enhance ecological sustainability through sustainable development. There are 8 national missions under NAPCC which encompasses The National Mission for a Green India and National Mission on Sustainable Agriculture and Carbon farming directly supports these missions under NAPCC by promoting carbon sequestration, climate- smart agriculture and sustainable land management.
- **National Mission on Sustainable Agriculture:** The National Mission on Sustainable Agriculture (2014-15) is a key component of the National Action Plan on Climate Change (NAPCC) which considers the sustainable use of land and resources under agriculture. It promotes subsidies and financial help to encourage the adoption of climate-resilient technologies, efficient use of water resources, conservation tillage techniques, all of which contribute towards carbon farming.
- **Soil Health Card Scheme:** This scheme launched by the GOI on 19 Feb, 2015, guides farmers on soil improvement by providing them with a printed report on their soil's nutrient status (12 parameters like NPK, micronutrients, pH etc.) improving soil fertility and productivity which enhances soil's capacity for carbon sequestration, a core aspect of carbon farming.
- **National Agroforestry policy and sub-mission on agroforestry (SMAF):** India was the first country in the world to adopt agroforestry policy on 2014. Its main agenda is to integrate trees with crops and livestock which increases productivity, income, and environmental resilience. SMAF was launched in 2016 onwards under National Mission for Sustainable Agriculture (NMSA). Its main objective is to promote farmers to adopt agroforestry by providing financial assistance for nursery, sapling distribution,

and plantation.

- **Carbon Credit Trading Scheme:** The Carbon Credit Trading Scheme, 2023 introduced under the Energy Conservation (Amendment) Act, 2022, replaces the Perform, Achieve, and Trade (PAT) scheme to establish the Indian Carbon Market (ICM), aligning with India's climate commitments under the Paris Agreement. The CCTS is a market-based mechanism to decarbonize the Indian economy by pricing greenhouse and facilitates carbon trading. It issues Carbon Credit Certificates (CCC) each representing 1 ton CO<sub>2</sub> equivalent reduction.

#### Challenges in the adoption of Carbon farming:

Despite its potential for climate change mitigation and sustainable agriculture, the adoption of carbon farming is hindered by multiple challenges. One of the major barriers is economic uncertainty associated with carbon farming practices. Farmers face high initial costs for adopting practices such as cover cropping, agroforestry, etc., while financial returns from carbon credits are delayed and uncertain. Lack of knowledge, training and awareness about the mechanism and benefits of carbon farming further limits its adoption. A 2022 survey by the National Bank for Agriculture and Rural Development (NABARD) revealed that most of Indian farmers were unaware of carbon farming opportunities.

Additionally, limited technical expertise on measurement, reporting and verification (MRV) of soil carbon is a significant challenge. It is very difficult to accurately measure soil carbon changes over time. High cost of monitoring and verification particularly for small landholders limits this practice.

Limited access to carbon markets, especially in developing countries and insufficient digital and institutional infrastructure for participation in carbon trading poses threat in the extension of carbon farming techniques.

#### Future Directions to Enhance Carbon Farming:

- **Scalable MRV System:** Applying knowledge of artificial intelligence (AI), machine learning (ML), satellite imagery, and remote sensing to develop cost-effective, transparent, and credible MRV system which is essential for wider adoption across various farm sizes.
- **Policy support and incentives:** Establishing farmer-friendly policies like simplified certification processes, subsidies for initial investments and assured minimum carbon credits prices to mitigate market fluctuation. Integration of carbon farming into national climate action plans and agricultural policies.
- **Precision Agriculture:** Use of IoT devices and drones for hyper-customized advisories for irrigation, nutrient management, and yield optimization. This helps farmers adapt to new practices and minimizes the overall environmental footprint of farming operations.

- **Capacity building & farmer awareness:** Encouraging training programs, demonstrations and extension services for farmers helps in wider adaptability of carbon farming practices. Carbon farming concepts are to be integrated in agricultural education and curricula.
- **Research & Innovation:** Enhancing research practices to develop low-cost, high impact carbon farming practices. Development of improved crop varieties with deeper root systems and higher biomass can increase carbon inputs in soil.

### Conclusion:

Carbon Farming provides a crucial way to achieve the goal of climate change mitigation through on-site carbon sequestration and reduction of greenhouse gas emission. It also considers its role in sustainable agriculture development, food security, and supply of multiple ecosystem services. Additionally, the potential for monetization through carbon credits provides economic incentives for farmers, especially for rural communities, making carbon farming both environmentally and economically viable. Techniques like agroforestry, cover cropping, management of livestock, crop residues and biochar application enhances soil organic carbon, improves soil structure and biodiversity. Therefore, promoting carbon farming through supportive policies, awareness programs and scientific innovation is essential for achieving the global target of sustainable development.

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