Carbon Farming: Harnessing Agriculture for Carbon Sequestration

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Introduction

Climate change is increasingly threatening agricultural productivity, ecosystem stability, and worldwide food security. Increasing levels of greenhouse gases in the atmosphere are accelerating global warming, leading to frequent droughts, floods, and extreme weather events. Agriculture accounts for a considerable proportion of global greenhouse gas emissions through soil disturbance, fertilizer application, livestock production, and land-use change. However, agricultural landscapes also possess enormous capacity to absorb carbon dioxide from the atmosphere through natural biological carbon sequestration process (FAO, 2017).

Carbon farming has recently gained attention as an effective climate-smart agricultural strategy that integrates sustainable farming practices to capture atmospheric carbon and store it in soils and plant biomass. In contrast to traditional farming practices that often deplete soil organic carbon, carbon farming helps improve soil fertility and also lowers greenhouse gas emissions. As a result, carbon farming provides environmental, economic, and social benefits, positioning it as a key element in sustainable agriculture and climate mitigation strategies (Lal, 2004).

Concept of Carbon Farming

Carbon farming refers to the adoption of agricultural management practices that increase carbon storage in vegetation and soils while minimizing the greenhouse gas emissions. Its main goal is to transform agricultural lands from net source of carbon emissions into carbon sinks through sustainable and improved land management practices. Carbon sequestration occurs through photosynthesis, where plants absorb atmospheric CO_2 and convert it into biomass (IPCC, 2022). A significant proportion of this carbon enters the soil through roots, crop residues, and microbial activity, increasing soil organic carbon stocks. The effectiveness of carbon farming depends on the adoption of regenerative farming practices that promote healthy soils and resilient ecosystems (World Bank, 2021).

Carbon Sequestration in Agricultural Systems: Carbon sequestration involves capturing atmospheric carbon dioxide and storing it for extended periods in soils, vegetation, or biomass. Agricultural soils represent one of the largest terrestrial carbon reservoirs. Enhancing soil organic carbon promotes soil fertility, enhances water retention, reduces erosion, and promotes microbial diversity. Several sustainable agricultural practices contribute to enhanced carbon sequestration by increasing biomass production, minimizing soil disturbance, and improving nutrient cycling.

Major Carbon Farming Practices

1. Cover Cropping: Cover cropping involves growing crops during fallow periods to maintain continuous soil cover. Frequently grown cover crops such as legumes, grasses and brassicas. The Benefits of cover cropping are increased soil organic carbon levels, enhances nitrogen fixation, reduce soil erosion, enhances water infiltration, suppresses weeds and enhances carbon sequestration. Continuous biomass production from cover crops contributes significantly to long-term soil carbon accumulation.

2. No-Till Farming: Conservation tillage or no-till farming minimizes soil disturbance by directly planting seeds into undisturbed soil. No till farming reduces oxidation of soil organic carbon, maintains soil structure, improves soil moisture conservation, decreases fuel consumption, reduces erosion and enhances microbial diversity. No-till farming significantly reduces carbon losses while increasing long-term carbon storage.

3. Agroforestry: Agroforestry is a sustainable land management approach that combines trees with crops and livestock to create multifunctional farming systems. Through photosynthesis, trees absorb carbon dioxide from the atmosphere and store carbon in roots, litter, and soil organic matter. Environmental Benefits are carbon sequestration, biodiversity conservation, improved nutrient cycling, reduced wind erosion, enhanced microclimate, increased farm resilience. Agroforestry is widely regarded as one of the most effective biological carbon sequestration strategies.

4. Perennial Cropping Systems: Unlike annual crops, perennial crops continue to grow and produce yields over multiple years, reducing soil disturbance and increasing belowground carbon storage. Deep root systems

continuously deposit organic carbon into soil while improving soil aggregation.

5. Soil Health Enhancement: Healthy soils form the foundation of sustainable agriculture and carbon farming. Enhancing soil organic matter improves the water-holding capacity, nutrient availability, soil biodiversity, carbon storage and crop productivity. Two important soil amendments include compost and biochar.

6. Environmental Benefits of Carbon Farming: Carbon farming delivers multiple ecosystem services beyond carbon sequestration. These benefits encompass climate change mitigation, enhanced soil fertility, reduced soil erosion, increased drought resilience, better water conservation, reduced nutrient runoff and improved ecosystem stability.

7. Economic and Policy Dimensions: Successful implementation of carbon farming depends upon supportive policies and financial incentives. Governments and international organizations increasingly encourage adoption through carbon credit programs, green subsidies, climate-smart agriculture initiatives, technical assistance, farmer education programs and sustainable land management incentives. These policies help reduce adoption costs while rewarding ecosystem services.

7.1 Carbon Credits: Carbon credit markets compensate farmers for verified carbon sequestration. Benefits includes additional farm income, encouragement of sustainable practices, promotion of low-carbon agriculture and support for climate mitigation

7.2 Government Programs: Several countries have launched policies and programs promoting sustainable agriculture through research funding, extension services, training programs, financial assistance and carbon accounting systems. Such initiatives accelerate the large-scale adoption of carbon farming (USDA, 2022).

8. Challenges and Future Perspectives: Despite its benefits, carbon farming faces several challenges *viz*., High initial implementation costs, limited farmer awareness, inadequate carbon measurement techniques, uncertain carbon market prices, lack of standardized verification systems and policy inconsistencies. Research in the future should prioritize the advancement of carbon monitoring technologies, developing climate-resilient farming systems, expanding carbon markets, and integrating digital agriculture with carbon accounting.

Conclusion

Carbon farming is widely recognized as a highly promising nature-based approach for alleviate climate change while improving agricultural sustainability. Practices such as cover cropping, no-till farming, agroforestry, perennial cropping, composting, and biochar application substantially increased soil carbon sequestration, improve soil health, enhance biodiversity, and strengthen farm resilience. Economic incentives, supportive government policies, and expanding carbon markets are essential for accelerating adoption. As global efforts intensify to achieve climate neutrality and sustainable food systems, carbon farming offers a practical pathway toward transforming agriculture from a major greenhouse gas emitter into an effective carbon sink. Continued research, policy support, and farmer engagement will be critical for realizing the full potential of carbon farming in achieving global climate and sustainability goals.

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