



Carbon Farming: A Pathway to Sustainable Agriculture and Climate Mitigation

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Climate change poses significant challenges to global agriculture, affecting crop productivity, soil health and food security. Carbon farming has emerged as a sustainable land management approach that enhances the sequestration of atmospheric carbon dioxide in soils and vegetation while improving agricultural productivity. Practices such as conservation tillage, cover cropping, agroforestry, crop rotation, organic amendments and biochar application contribute to increasing soil organic carbon stocks and reducing greenhouse gas emissions. In addition to environmental benefits, carbon farming improves soil fertility, water retention, biodiversity and farm resilience. Furthermore, participation in carbon credit markets can provide additional income opportunities for farmers. This article discusses the principles, practices, benefits, challenges and future prospects of carbon farming as a climate-smart agricultural strategy.

Keywords: Carbon farming, Carbon sequestration, Climate change mitigation, Soil organic carbon, Sustainable agriculture

Introduction

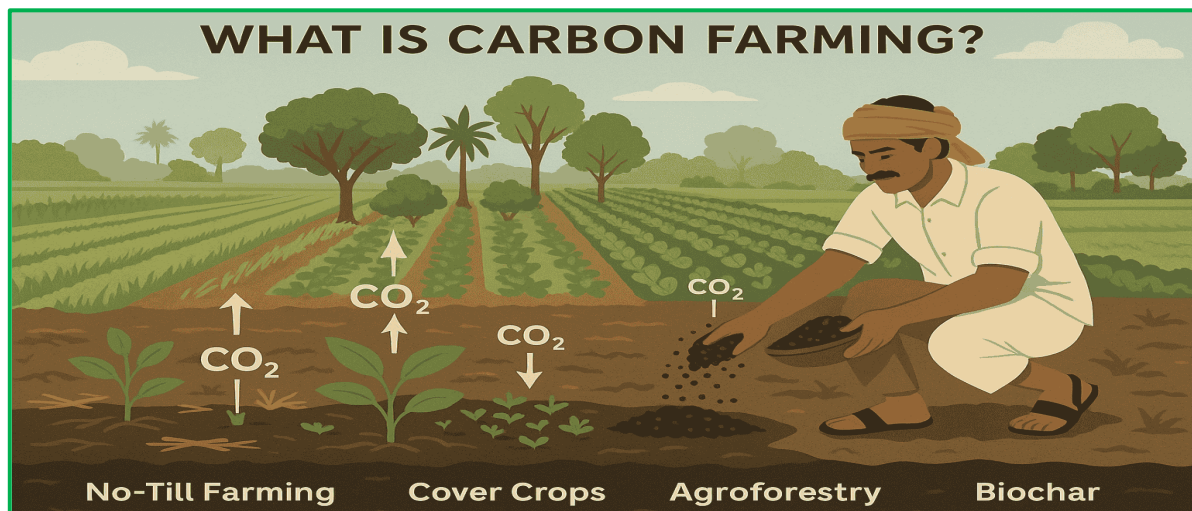
Agriculture is the backbone of human civilization, providing food, fiber, fuel and livelihoods to billions of people worldwide. However, modern agricultural systems face numerous challenges, including declining soil fertility, land degradation, biodiversity loss, water scarcity and climate change. The increasing concentration of greenhouse gases (GHGs), particularly carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O), has accelerated global warming, resulting in rising temperatures, erratic rainfall patterns, frequent droughts, floods and extreme weather events. These changes threaten agricultural productivity and global food security. The agricultural sector contributes approximately one-fourth of global greenhouse gas emissions through intensive tillage, excessive fertilizer use, deforestation, residue burning and livestock production. Therefore, there is an urgent need for sustainable agricultural practices that can simultaneously enhance productivity, improve soil health and reduce environmental impacts.

Carbon farming has emerged as a promising solution to these challenges. It refers to a set of agricultural practices designed to capture atmospheric carbon dioxide and store it in soils, plants and biomass. Through natural biological processes such as photosynthesis, plants absorb carbon from the atmosphere and convert it into organic matter. Carbon farming enhances this process by adopting management practices that increase carbon sequestration while minimizing carbon losses. Beyond climate mitigation, carbon farming improves soil structure, increases water-holding capacity, enhances nutrient availability, promotes biodiversity and strengthens farm resilience against climate stresses.

What is Carbon Farming?

Carbon farming is a system of land management practices aimed at increasing the amount of carbon stored in vegetation and soils. Through photosynthesis, plants absorb carbon dioxide from the atmosphere and convert it into organic matter. A portion of this carbon is transferred to the soil through roots, crop residues and organic amendments.

- The primary goal of carbon farming is to enhance this natural process and retain carbon in agricultural ecosystems for long periods.



Importance of Carbon Farming

1. Climate Change Mitigation

Atmospheric carbon dioxide is one of the major greenhouse gases responsible for global warming. Carbon farming helps remove CO₂ from the atmosphere and stores it in soils, thereby reducing the concentration of greenhouse gases.

2. Improved Soil Health

Soil organic carbon is a key indicator of soil fertility. Increased carbon levels improve soil structure, water-holding capacity, nutrient availability and microbial activity.

3. Enhanced Crop Productivity

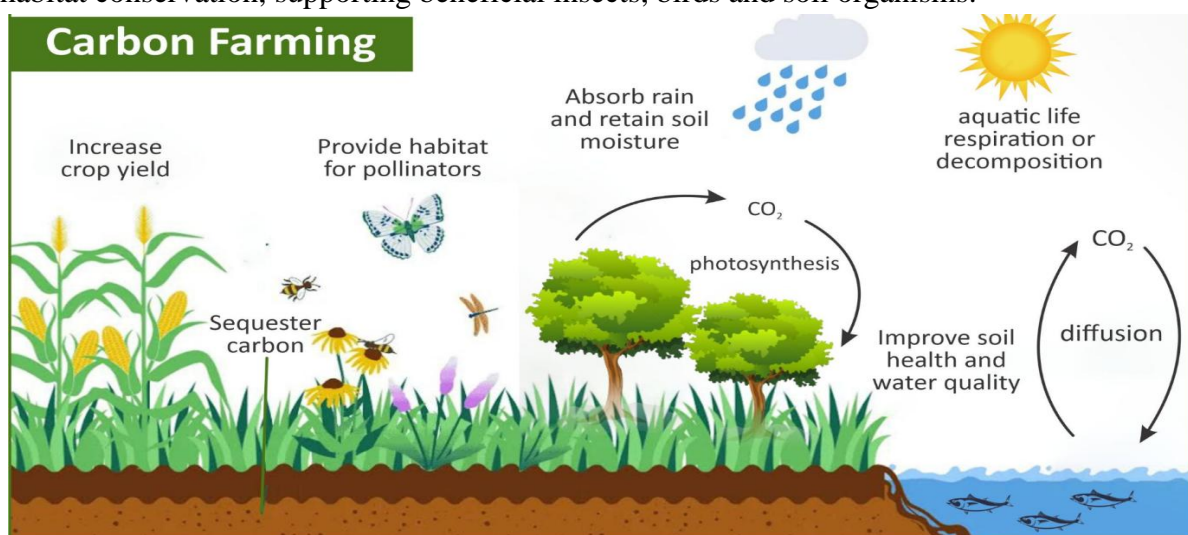
Healthy soils rich in organic carbon support better root growth and nutrient uptake, resulting in higher crop yields and improved crop resilience.

4. Water Conservation

Carbon-rich soils can retain more moisture, reduce irrigation requirements and help crops withstand drought conditions.

5. Biodiversity Enhancement

Carbon farming practices often promote diversified cropping systems, agroforestry and habitat conservation, supporting beneficial insects, birds and soil organisms.



Key Carbon Farming Practices

1. Conservation Tillage

Conventional tillage disturbs soil structure and releases stored carbon into the atmosphere. Conservation tillage or zero tillage minimizes soil disturbance and helps retain soil carbon.

2. Cover Cropping

Cover crops such as legumes, grasses and green manures protect the soil surface, reduce erosion and contribute organic matter to the soil.

3. Crop Rotation

Diverse crop rotations improve soil fertility, break pest cycles and increase carbon inputs through varied root systems and crop residues.

4. Agroforestry

Integrating trees with crops and livestock systems enhances carbon sequestration both above and below ground while providing additional economic benefits.

5. Organic Amendments

Application of farmyard manure, compost, crop residues and biochar increases soil organic carbon and improves soil quality.

6. Integrated Nutrient Management

Combining organic and inorganic nutrient sources promotes sustainable soil fertility while enhancing carbon storage.

7. Improved Grazing Management

Rotational grazing and pasture improvement increase biomass production and carbon storage in grassland ecosystems.

Carbon Sequestration in Soil

Soils represent one of the largest terrestrial carbon reservoirs. Carbon sequestration occurs when carbon inputs exceed carbon losses. Factors influencing soil carbon sequestration include:

- Climate
- Soil type
- Cropping system
- Land management practices
- Organic matter additions

Research indicates that adopting sustainable land management practices can significantly increase soil organic carbon stocks over time.

Role of Biochar in Carbon Farming

Biochar is a carbon-rich material produced by heating biomass under limited oxygen conditions. It is highly stable and can remain in soils for hundreds of years.

Benefits of biochar include:

- Long-term carbon storage
- Improved soil fertility
- Enhanced water retention
- Reduced nutrient losses
- Increased microbial activity

Due to its stability, biochar is considered a promising tool for climate-smart agriculture.

Carbon Credits and Carbon Markets

Carbon farming can generate economic opportunities for farmers through carbon credit programs. When farmers adopt practices that increase carbon sequestration or reduce greenhouse gas emissions, they may earn carbon credits.

These credits can be sold in voluntary or regulated carbon markets, providing additional income while encouraging sustainable agricultural practices.

Challenges in Carbon Farming

Despite its potential, carbon farming faces several challenges:

- Limited awareness among farmers
- Difficulty in measuring soil carbon changes
- High monitoring and verification costs
- Lack of technical expertise
- Policy and institutional constraints
- Long time required to observe significant carbon accumulation

Addressing these challenges requires research support, capacity building and favourable policies.

Carbon Farming in India

India has immense potential for carbon farming due to its vast agricultural area and diverse agroecosystems. Practices such as conservation agriculture, agroforestry, organic farming and integrated nutrient management are increasingly being promoted. Government initiatives focusing on climate-resilient agriculture, soil health improvement and sustainable land management can further accelerate carbon farming adoption. Programs encouraging soil organic carbon enhancement can contribute significantly to India's climate goals while improving farmer livelihoods.

Future Prospects

The future of carbon farming is promising as governments, researchers and international organizations recognize the importance of nature-based solutions for climate change mitigation. Advances in carbon measurement technologies, digital agriculture and carbon markets are expected to enhance adoption rates. Carbon farming aligns with the principles of sustainable agriculture by balancing environmental protection, economic viability and social well-being. It represents a practical strategy for achieving food security while combating climate change.

Future priorities include:

- Expanding carbon credit programs.
- Promoting climate-smart agriculture.
- Supporting farmer training and awareness.
- Encouraging public-private partnerships.
- Integrating carbon farming into national climate policies.

Conclusion

Carbon farming offers a better solution for agriculture and the environment. By capturing atmospheric carbon and storing it in soils and vegetation, it helps mitigate climate change while improving soil health, water conservation, biodiversity and crop productivity. As global efforts to address climate change intensify, carbon farming has the potential to become a cornerstone of sustainable agricultural development. Promoting awareness, supportive policies and farmer participation will be crucial in realizing its full potential and ensuring a resilient agricultural future.